PB-240 084

RADIATION DATA AND REPORTS. VOLUME 14, NUMBERS 1-3, JANUARY-MARCH 1973

Office of Radiation Programs
Washington, D. C.

March 1973

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET

1. Report No.
RDDRA 14 (1-3)

2.

PB 240 084

4. Title and Subtitle
Radiation Data and Reports
Volume 14, Nos 1-3

5. Report Date
Jan-Mar 1973

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Jan-Mar 1973

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented.

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

17c. COSATI Field/Group

18. Availability Statement
Release unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
232

22. Price PC/MF
7.50/2.25

I

RADIATION DATA AND REPORTS

Volume 14, Number 1, January 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

Page

REPORTS

Technology Assessment of Risk Reduction Effectiveness of Waste Treatment Systems for Light-Water Reactors 1
J. E. Martin, F. L. Galpin, and T. W. Fowler

Assessment of Thyroid Inhalation Doses in the Western United States from the Chinese Nuclear Test of November 1971 9
R. B. Evans, R. N. Snelling, and F. N. Buck

DATA

SECTION I. MILK AND FOOD 17

Milk Surveillance, September 1972 17

Food and Diet Surveillance 26

SECTION II. WATER 27

Gross Radioactivity in Surface Waters of the United States, May 1972 28

Tritium Surveillance System, April-June 1972 31

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION ---------------- 35

Radioactivity in Airborne Particulates and Precipitation ---------------- 35

1. Radiation Alert Network, September 1972 -------- 36
2. Canadian Air and Precipitation Monitoring Program, September 1972 -------- 38
3. Pan American Air Sampling Program, September 1972, *PAHO and EPA* -------- 39
4. California Air Sampling Program, September 1972 -------- 39
5. Mexican Air Monitoring Program, May-August 1972 -------- 41
6. Plutonium in Airborne Particulates, April-June 1972 -------- 42

Air Surveillance Network, September 1972 -------- 43

SECTION IV. OTHER DATA -------- 47

Strontium-90 in Human Bone, October-December 1971 -- 47

Environmental Levels of Radioactivity at Atomic Energy Commission Installations -------- 50

1. Knolls Atomic Power Laboratory, January-December 1970 -------- 50
2. Mound Laboratory, January-June 1970 -------- 54

Reported Nuclear Detonations, December 1972 -------- 57

Synopses -------- iii

Guide for Authors --------Inside back cover

RADIATION DATA AND REPORTS

Published under the direction of

W. D. Rowe
Deputy Assistant Administrator
for Radiation Programs

BOARD OF EDITORIAL ADVISORS

Capt. Myron I. Varon, MC, USN
Department of Defense
Dr. Milton W. Lammering
Environmental Protection Agency
Leo O. Tiffin
Department of Agriculture
Dr. Randall S. Caswell
Department of Commerce
Robert E. Simpson
Department of Health, Education, and Welfare
Dr. Martin B. Biles
Atomic Energy Commission

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary H. Nesdore
Illustrator	Marylee C. Hill

Address correspondence to the Editor, *Radiation Data and Reports*, Office of Radiation Programs, Parklawn 18B-40, Washington, D.C. 20460.

For subscriptions to *Radiation Data and Reports*, please use the order form on last page of this issue.

U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

2

Reports

Technology Assessment of Risk Reduction Effectiveness of Waste Treatment Systems for Light-Water Reactors

James E. Martin, Floyd L. Galpin, and Ted W. Fowler[1]

The Environmental Protection Agency (EPA) routinely performs technology assessment of applications of nuclear energy that have the potential to introduce radioactive material into the environment. The Agency has extensively examined the performance of waste treatment systems for light water power reactors as a function of cost with regard to an examination of bases for environmental radiation standards and for EPA review of environmental impact statements for such plants. It was determined that significant and cost effective offsite dose reductions from gaseous discharges could be brought about by using available technology to hold up the gases until essentially krypton-85 remained; further dose reductions by cryogenic removal of krypton-85 did not appear to be justified in view of the costs involved. Similarly for liquid wastes, reasonable technology appears to stop just short of recycling waste streams to contain tritium.

The Environmental Protection Agency (EPA) considers the environmental impact of nuclear power facilities within two major activities; (1) the development of environmental radiation standards, and (2) making public comments on environmental impact statements submitted on such facilities relative to the National Environmental Policy Act. A major consideration in the assessment programs supporting these activities is the design and use of waste treatment systems to process radioactive materials prior to their discharge to the environment. The potential amount of such materials that may be released is usually determined by fuel cladding performance; the actual quantities discharged to the atmosphere or receiving waters are by and large determined by the amount of waste treatment prior to discharge. Although the greatest reduction in population dose would obviously be associated with complete removal of radionuclides from discharge effluents, it is apparent that a point of practicality is reached beyond which the degree of dose reduction achieved is not justified by the cost of the system required. The purposes of this paper are to analyze dose reductions that are obtained by the design or operation of augmented waste treatment systems and to present a general analysis of some of the known costs involved in achieving these reductions.

The EPA used several sources of information in its analysis of the performance and costs of waste treatment technology. Data which characterize the quantity and types of radionuclides discharged were derived from selected safety analysis reports and environmental reports submitted by applicants for licenses for nuclear power stations. These design and environmental reports have been reviewed in considerable detail relative to public health and environmental effects by EPA and its predecessor organization for several years. The source term characteristics of both boiling water reactors (BWR) and pressurized water reactors (PWR) were independently confirmed by field studies carried out at operating facilities. These field studies were also used as a basis for estimated doses to offsite populations on the basis of measurements of the significant pathways of exposure.

Waste treatment effectiveness

Expected dose rates from both PWR's and

---

[1] Technology Assessment Division, Office of Radiation Programs, Environmental Protection Agency, 5600 Fishers Lane, Rockville, Md. 20852.

BWR's were conservatively considered on the basis of the radioactive waste discharges projected by the major reactor vendors because of fuel failures. Both the liquid and gas waste treatment systems are designed to process the wastes expected to be generated when these fuel failure conditions exist. Gas waste treatment systems depend on physically capturing and storing gaseous radionuclides to allow them to undergo radioactive decay to concentrations such that, once they are vented to the atmosphere for dispersal, offsite doses will be well below established guidelines. The method of retention varies with reactor type, the volume of gas to be processed, and the required holdup period. Liquid waste systems depend on methodology to filter, demineralize, and solidify radioactive materials out of process streams that may eventually be discharged to the aquatic environment.

Gases from pressurized water reactors (PWR)

Current PWR's handle small volumes of radioactive gases; therefore, a system of tank storage for 30–90 days decay is used, with subsequent discharge through a building vent. Table 1 illustrates a design source term typical of a 1,100 megawatt (electric) [MW(e)] PWR (*1*) and the effectiveness of increasing holdup to reduce all components of the gas mixture except krypton–85. The capacity of systems for most PWR's is sufficient to provide 60 days holdup; with this decay period, discharges are almost solely krypton–85, a low-energy beta emitter with minimal dosimetric significance for normal operating conditions as well as assumed design conditions leading to maximum routine releases. Using design data for several proposed PWR plants which assumed 1 percent failed fuel, the maximum estimated offsite dose rates as shown in table 2 from a typical 1,100 MW(e) plant were 20, 4.3, 2.0, and 1.6 mrem/year for holdup times of 15, 30, 45 and 60 days, respectively. These same data, expressed as the ratio of the dose rate at zero holdup to the reduced dose rate after holdup, are plotted in figure 1 as a function of holdup time. The curve in figure 1 begins to flatten around 45 days, indicating that exposures to individuals at the site boundary decrease only slightly for longer

Table 1. Typical 1,100 MW(e) PWR source term [a] (1 percent failed fuel)

Days decay	Radionuclides (Ci/year)			
	Krypton-85	Xenon-131m	Xenon-133	Other gases
7	11,900	6,000	390,000	<600
15	11,900	3,800	140,000	<50
30	11,900	1,600	20,000	<1
45	11,900	600	2,700	0
60	11,800	300	400	0
90	11,700	50	10	0

[a] Based on average of discharges estimated in safety analysis reports for the North Anna, Palisades, and Arkansas Nuclear One—Unit 2 plants.

Table 2. Typical offsite whole-body dose rates for a 1,100 MW(e) PWR with 1 percent failed fuel (from gaseous emissions)

Days holdup	mrem/year	Dose reduction factor
0	180	1
15	20	9
30	4	45
45	2	90
60	1.6	110
90	1.5	120

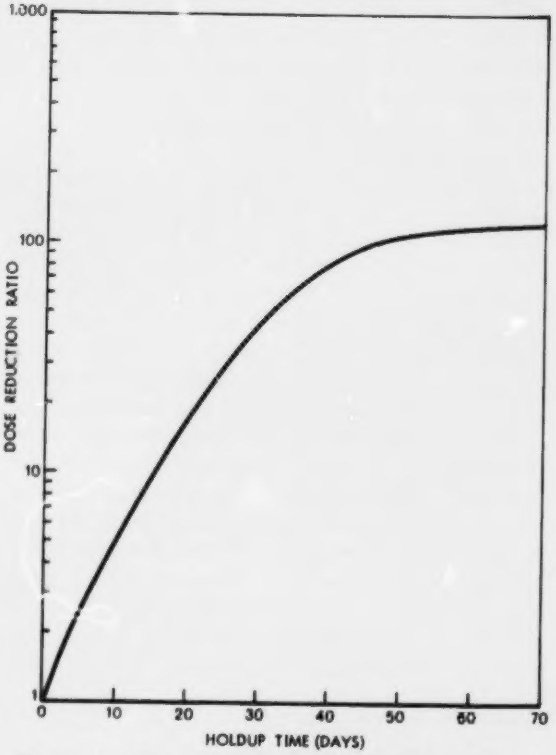

Figure 1. Dose reduction factor vs. holdup time for a "typical" PWR

holdup periods. Since krypton–85 has a 10.76 year half-life, use of holdup tanks beyond 45–60 days has little further effect in reducing the dose rate. On the other hand, the resulting radiological effects associated with the small quantities of this beta emitter will be negligible. Further reduction could only be achieved by removing the krypton–85 from the off-gas stream.

The above data, which are for a typical PWR, appear to be conservative when compared to actual estimates being made for new generation PWR plants. For example, discharge estimates for the Surry Nuclear Power Station (*2*) which are presented in table 3 (adjusted to 1 percent failed fuel) indicate that both discharges and offsite dose rates could be about one-fourth those determined for the typical plant selected. It is perhaps significant that these low dose rates pertain to achievable reductions by holdup of gases in the main gas processing system. Relatively speaking, therefore, once the primary source has been processed, the secondary gaseous sources, such as turbine building exhaust, general ventilation, etc., may well become the predominant source of offsite dose from PWR's.

Gases from boiling-water reactors

Until recently, a BWR waste treatment system of typical design handled large volumes of radioactive gases by delaying them for about 30 minutes and discharging them through a tall stack (about 100 meters) to the atmosphere. Current reactor license applications indicate that several systems have recently become available to provide longer holdup periods with discharge usually through a building vent rather than a stack. Systems which have been proposed to obtain this holdup (*3*) and the resulting dose reductions usually include catalytic recombiners (to reduce gas volume) followed by either: (1) low temperature or cryogenic adsorption on charcoal; (2) gas storage under pressure; or (3) in some cases, cryogenic distillation. Although not all systems have been operated in full-scale BWR's, EPA consultations with various vendors of gaseous waste management systems indicate that such systems can reduce quantities of radioactive materials in gaseous emissions from BWR's such that resulting exposures to individuals in the general environment are low. Using estimated discharge data for typical 1,000 MW(e) boiling-water power reactors, for example, it has been estimated that discharge of the effluent from a building vent after 25 days holdup would produce a maximum dose rate offsite of about 6 mrem/year; for 45 and 60 days, the dose rate would be about 0.7 and 0.3 mrem/year, respectively, mostly from krypton–85. These data are shown in table 4 and are plotted as dose reduction factors in figure 2. If the effluents are discharged through a stack instead of a vent following such holdup periods, expected dose rates would be about 0.1, 0.01, and 0.005 mrem/year, respectively.

It appears from discussions with industry that the most common holdup systems from the standpoint of size, design, performance, and cost using charcoal adsorption are for holdup periods of about 25–30 days with discharge of the processed effluent through a building vent.

Table 3. Estimated offsite dose rates for one unit of the Surry (PWR) Nuclear power station at 822 MW(e) with 1 percent failed fuel [a]

Days holdup	Annual gaseous discharge rates (Ci/year)				Offsite dose (mrem/year)[b]
	Krypton-85	Xenon-131m	Xenon-133	Total	
15	2,910	1,400	77,200	81,500	10.7
30	2,900	582	10,700	14,200	1.86
45	2,890	242	1,500	4,630	.60
60	2,809	100	208	3,190	.42
90	2,870	17	4	2,890	.38

[a] Data presented in Surry Environmental Impact Statement (*2*) were for 0.25 percent failed fuel; adjusted to 1 percent for this table. Data are for gas processing systems only and do not consider secondary gaseous releases.

[b] Based on dispersion factor of 2.5×10^{-6} s/m^3 and the weighted mixture of gaseous radionuclides in the table.

5

Table 4. Estimated offsite dose rate (mrem/year) from gaseous emissions for typical 1,000 MW(e) BWR [a]

Holdup period	100 m stack discharge	Vent discharge
30 minutes	500	—
1 day	8	420
3 days	2.0	110
9 days	.8	45
25 days	.1	6
45 days	.01	.7
60 days	.005	.3

[a] Data normalized to source term which after 30 minutes decay would yield 500 mrem/year at typical site boundary.

These conditions would result in maximum offsite individual exposure of about 6 mrem/year for the upper design assumptions of leaking fuel. Discharge of the processed effluent through a stack after 25–30 days holdup would give a further reduction in dose to about 0.1 mrem/year at substantial increment of cost. Any given exposure rate criterion can be met by shorter holdup periods if a stack is used because of the additional dilution obtained between the points of discharge and exposure. Although the same maximum dose rate would result by substituting a stack for increased holdup capacity, a higher man-rem dose might occur from dispersing a larger amount of radioactivity into the atmosphere.

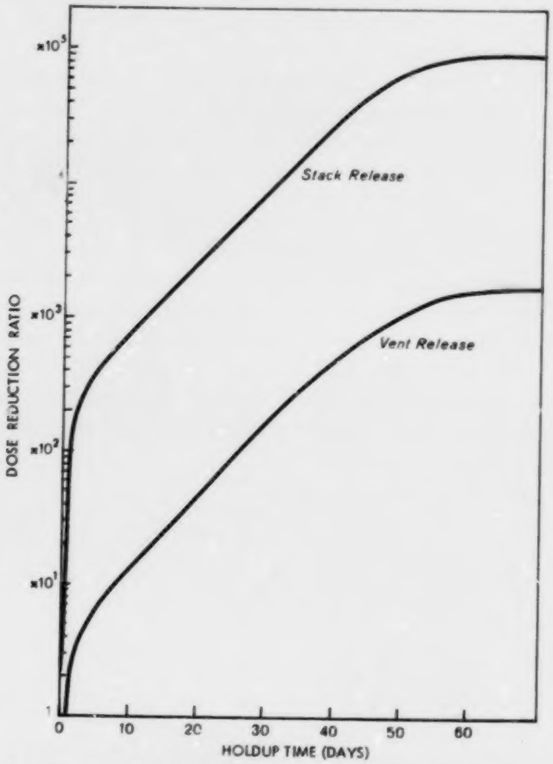

Figure 2. Dose reduction ratio vs. holdup time for gaseous emissions from a "typical" 1,000 MW(e) BWR

Cost effectiveness of treatment systems—liquid wastes

Treatment of liquid wastes for both PWR's and BWR's depends on the same general techniques of filtration, demineralization, and solidification by evaporation or other means so that the majority of the radioactive material is removed from process streams and disposed of as solid wastes by shipment offsite to licensed burial facilities. Most facilities already incorporate designs that allow subsequent dose rates to individuals of 1 mrem/year or less to be achieved, even allowing for discharges of tritium. Increased costs may be required to upgrade some reactor systems currently operating in order to reach these levels of exposure, but such costs would be within a range that numerous utilities have already accepted as commercially feasible by installing such equipment. EPA field studies conducted to date at both operating PWR's (4) and BWR's (5) confirm that population exposures from liquid waste discharges are relatively small in comparison to gaseous discharges, and are virtually impossible to determine in the general environment.

PWR gaseous waste treatment

Current gaseous waste treatment system designs for PWR's are, by and large, able to provide sufficient holdup (about 60 days) to reduce discharges to essentially krypton-85; therefore, no substantial incremental costs above those already being expended would be required for PWR's to meet this criterion. The only dose reductions that could be achieved by additional expenditures for PWR's would be to remove krypton-85 from the offgas streams by the use of cryogenic techniques or a combination of charcoal and cryogenic delay beds. The only dose reduction possible above that achieved with holdup systems of 60–90 days capacity is about 1.5 millirems per year for the 1 percent

Table 5. Cost effectiveness of PWR gaseous waste treatment systems in reducing annual dose rate

Dose data		Recombiner and holdup tanks			Recombiner plus cryogenic		
Days holdup	Annual dose (mrem)	Capital cost ($10³)	Annual cost[a] ($10³)	Δ$ / Δmrem	Capital cost ($10³)	Annual cost ($10³)	Δ$ / Δmrem
0	181	0	0	—	0	0	
1	152	[b]400	60	2,100	400	[c]60	2,100
15	20	500	74	105	—	—	—
30	4.3	600	88	810	—	—	—
45	2.0	700	102	6,100	—	—	—
60	1.6	800	116	35,000	—	—	—
90	1.5	900	130	140,000	—	—	—
∞	0	—	—	--	1,000	[c]213	1,000

[a] Includes $25,000 annual operating cost for basic system; incremental annual cost of $5,000 assumed for each 15 days holdup added above recombiner. Based on 8 percent interest on capital cost.

[b] Costs for recombiner and holdup based on the Sequoyah Nuclear Power Station (6).

[c] Includes estimated annual operating costs of $100,000.

failed fuel situation in a 1,100 MW(e) reactor. The actual increment of dose reduction possible for most routine operations with good fuel performance is considerably less than 1.5 millirems per year. In essence, therefore, two options are available for gaseous waste treatment from PWR's: (1) holdup tanks (current design) to reduce discharges to krypton–85, and (2) recombiners followed by a cryogenic system (no tanks) to remove all noble gases for long-term storage. Relative costs of using each of these options in a typical 1,100 MW(e) plant, inclusive of operational costs, are shown in table 5. The data indicate that the annualized cost of complete removal of krypton–85 by cryogenic techniques is almost twice that of providing 45–60 days decay with holdup tanks.

Figure 3 is a plot of the data in table 5 for the tank treatment option; it illustrates that about 15 days holdup is the most cost effective provision of holdup capacity. Figure 3 also indicates that significant dose reductions versus cost are obtainable up to about 30–45 days, after which rapidly increasing costs would be incurred for small reductions in dose. This situation exists because essentially all of the remaining gas is krypton–85. The dose represented by this residual krypton–85 is only about 1.5 milirems per year for a typical PWR. The value or necessity for such a dose reduction is questionable since the computed dose represents a surface dose to the skin, not to viable tissue or genetically significant organs. Since krypton–85 is essentially a low energy emitter, the dose to the living layers of the skin would be approximately half the surface dose, and the genetic dose would be approximately 2.5 percent of the skin surface dose (7).

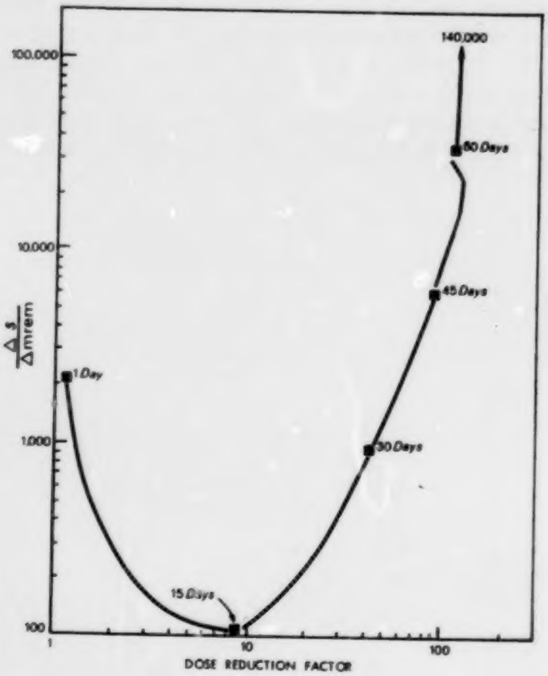

Figure 3. Cost effectiveness of PWR gaseous waste treatment (recombiner and holdup tanks)

BWR gaseous waste treatment

The cost of gaseous waste treatment for BWR's is a bit more complex than for PWR's,

7

primarily because most system designs for long holdup periods are relatively new with little actual experience on design, construction, and operating costs. Estimates of system costs are based on contractual work (*8*) and vendor discussions and are shown in figure 4. It appears from a number of recent environmental reports filed by utilities in support of license applications for BWR's that systems based on charcoal absorption beds may be retrofitted at a cost of about three to four million dollars for a 1,000 MW(e) plant (GE data in figure 4). This system could provide dose reduction factors of 100 to 1,000 above those currently available with delay lines and a stack. Cryogenic techniques can also be used to entrap the noble gases with subsequent storage for long periods. The installed cost of this system should be somewhat similar to the charcoal system, but the accompanying dose reduction factor may be a factor of 10 higher. The cryogenic systems apparently are not yet fully evaluated relative to potential system leakage and the redundancy that would be required for plants using them to be licensed. This lack of performance information is apparently the major reason that only a few of these have been proposed for BWR facilities.

The cost effectiveness of reducing potential annual offsite dose rates for a typical BWR is shown in figure 5 for three of the options that currently appear to be available to reactor designers. The first option is to add a catalytic recombiner and charcoal beds onto a system employing a 30-minute delay-line and a stack, a common retrofit situation for BWR's in operation or nearing completion. The second option would be to add a recombiner and charcoal beds to a system with a 30-minute delay-line and a building vent discharge. A third option which is available early in design would be to eliminate both the 30-minute delay-line and the stack and use only recombiners, charcoal beds, and vent discharge. If the design objective for

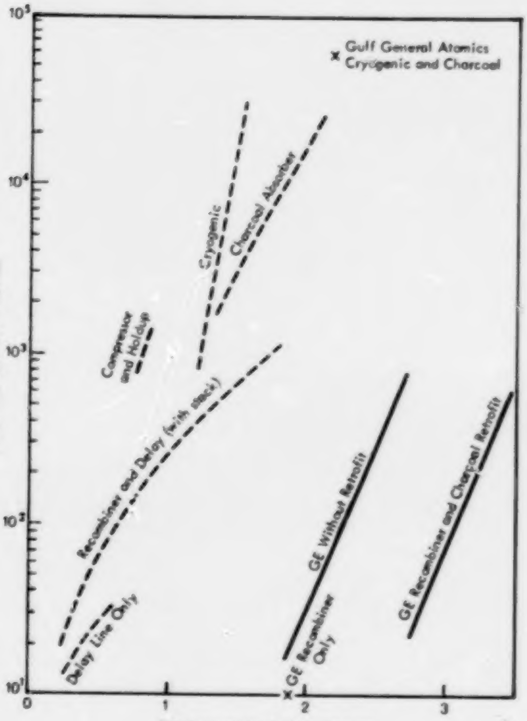

Figure 4. Cost of dose reduction for gaseous effluents at a BWR

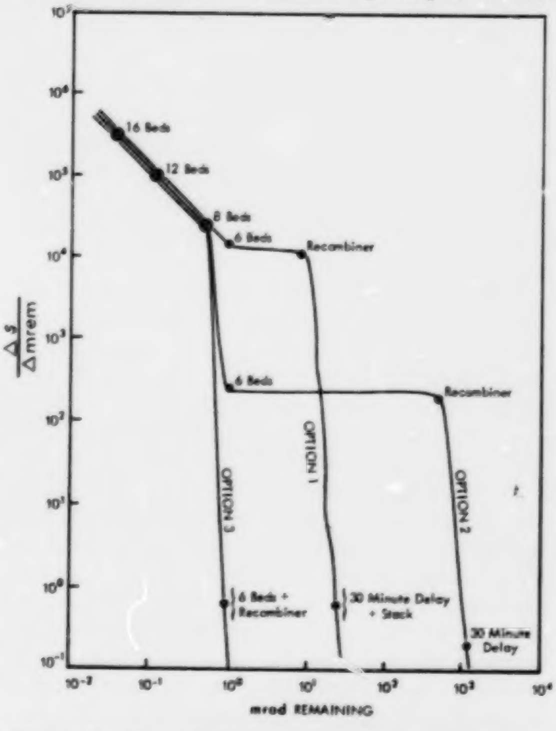

Figure 5. Cost effectiveness of adding various gas treatment components to achieve annual dose reduction to individuals offsite for a "typical" 1,000 MW(e) BWR

BWR's were to reduce potential offsite dose rates to less than 10 mrem/year, option 3 would be the most cost-effective approach. The cost data used in determining the cost effectiveness curves were obtained primarily from environmental reports for selected BWR power plants and are believed to reasonably reflect industry costs for such systems for BWR's.

Conclusions

On the basis of the foregoing analysis, it can be concluded that a typical 1,100 MW(e) PWR can normally be expected to operate such that dose rates for individuals at the maximum point offsite would be somewhere below about 1.5 mrem/year with systems currently being installed by the industry for liquid or gaseous waste treatment. Similarly, a BWR can be expected to operate so that exposures at the maximum point offsite would be less than about 6 mrem/year if gas holdup treatment equipment costing about three to four million dollars is retrofitted in the design. Further reductions in this dose for a BWR would require longer holdup periods (greater than 25–30 days) resulting in costs on the order of one-half million dollars per millirem reduced. Complete removal of krypton–85 from either PWR's or BWR's could cost from one-quarter to one million dollars per plant for exposure reductions in most cases of about 1 mrem/year or less. These estimated individual exposures offsite are dependent on the assumption that all systems are operational at all times. Failure rates or down times of such waste treatment systems are not generally known, but any technical conclusions relative to expected population dose rates from light-water reactors should consider that such systems would occasionally be out of service. It should also be noted that individual offsite dose rates presented in this paper are only doses attributable to the major gaseous radioactive waste treatment system. Secondary gas sources, such as containment purging, will add to the dose rates estimated for effluents from the waste treatment system.

Having once reduced gaseous effluents of light-water reactors to essentially krypton–85, the only further treatment that can be considered would be to remove the krypton–85 from the effluent and store it in pressurized tanks or cylinders for about 100 years to allow it to decay. Whether it is worth while or even desirable to exert further effort to contain the residual krypton–85 is doubtful at the present time. For most normal operating conditions, an expenditure of one-quarter to one million dollars is required for systems which would prevent less than 100 curies per year of krypton–85 from being discharged to the atmosphere, a relatively small quantity of radioactive material and generally negligible from an environmental or public health impact standpoint. This may be considered an unnecessarily drastic step for nuclear reactors since the major source of krypton–85 is that discharged from reactor fuel reprocessing facilities. Discharges at these facilities are several thousand curies per day; therefore, if reductions of krypton–85 are required from a public health standpoint, reductions of discharges to the atmosphere should first be made at these facilities. The Environmental Protection Agency has made such a recommendation in reviews of environmental impact statements for fuel reprocessing plants and the Atomic Energy Commission is conducting studies of systems to cope with this potential problem. Furthermore, the potential hazards associated with retaining cylinders of krypton–85 and methods for ultimate storage for about 100 years require further evaluation.

REFERENCES

(*1*) ENVIRONMENTAL PROTECTION AGENCY. Evaluation of technology for reducing potential radiation doses from gaseous effluents of light-water nuclear power plants, Unpublished report, TAD/ORP. Environmental Protection Agency, Rockville, Md. 20852 (July 1971).

(*2*) ATOMIC ENERGY COMMISSION. Final environmental statement, Surrey Power Station Unit 2. US. AEC, Directorate of Licensing, Washington, D.C. (June 1972).

(*3*) SMITH, JAMES M. Testimony before the State of Illinois Pollution Control Board on Quad-Cities Nuclear Station. Nuclear Energy Division, General Electric Company, San Jose, Calif. (May 24, 1971).

(4) KAHN, B., et al. Radiological surveillance studies at a pressurized water nuclear power reactor, Report No. RD 71-1. Office of Radiation Programs, Environmental Protection Agency, Rockville, Md. 20852 (August 1971).

(5) KAHN, B., et al. Radiological surveillance studies at a boiling water nuclear power reactor, Report No. BRH/DER 70-1. Office of Radiation Programs, Environmental Protection Agency, Rockville, Md. (February 1971).

(6) TENNESSEE VALLEY AUTHORITY. Environmental report, Sequoyah Nuclear Power Station. Tennessee Valley Authority, Chattanooga, Tenn.

(7) RUSSELL, J. L. and F. L. GALPIN. Comparison of techniques for calculating doses to the whole body and to the lungs from radioactive noble gases. Proceedings of the Topical Symposium of the Health Physics Society, Columbia Chapter, November 2–5, 1971, Richland, Wash. (February 1972).

(8) LEONARD, J. H., T. S. BAER, and L. E. ECKART. Techniques for reducing routine release of radionuclides from nuclear power plants, U.S. PHS Contract Report CPE-R-70-0015. University of Cincinnati, Cincinnati, Ohio (1971).

Assessment of Thyroid Inhalation Doses in the Western United States From the Chinese Nuclear Test of November 1971

R. B. Evans, R. N. Snelling, and F. N. Buck [1]

Following a nuclear detonation by the People's Republic of China, measurable increases of radioactivity were detected over the western United States by the Air Surveillance Network which is operated by the National Environmental Research Center-Las Vegas. The progress and intensity of the radioactive cloud across the United States are presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 0.2 mrem at Scotty's Junction, Nev.

The U.S. Atomic Energy Commission announced that the People's Republic of China detonated a nuclear device with a yield of about 20 kilotons in the atmosphere in the vicinity of its Lop Nor testing ground at 1:00 a.m., e.s.t., on November 18, 1971. Measurable increases in airborne radioactivity were subsequently detected over the continental United States by the Air Surveillance Network (ASN) beginning with samples collected on November 24, 1971 (*1*). The network, operated by the National Environmental Research Center-Las Vegas (NERC–LV), presently includes air sampling stations in 21 western States.[2] During November 1971, 103 ASN stations operated continuously. Gross beta concentrations ranging from 0.3 pCi/m^3 to 2.0 pCi/m^3 above background were first observed in Washington and Oregon, although the highest gross beta concentrations were ultimately found in samples from western Nevada and eastern California. The highest hypothetical infant thyroid dose equivalent resulting from inhalation of iodine–131 and tellurium–132 was slightly more than 0.2 mrem at Scotty's Junction, Nev., which is approximately 125 miles northwest of Las Vegas, Nev. (*2*). The Federal Radiation Council has recommended that the average radiation dose to the thyroids of a suitable sample of the general population be kept below 500 mrem per year. The value of 0.2 mrem calculated for Scotty's Junction is less than one-tenth of 1 percent of this radiation protection guide (*3*).

Gross beta concentrations in air

Twelve sampling stations were selected at random for a determination of background concentrations of gross beta radioactivity. The average gross beta concentrations and standard deviation were determined for the first 23 days of November. Values less than the minimum detectable concentration were ignored in this computation, thus raising the estimate of the average. The average gross beta concentration, i.e., background concentration, was found to be 0.15 pCi/m^3 with an average standard deviation of 0.06 pCi/m^3. For the purposes of detecting airborne radioactivity, values greater than 3 standard deviations above background (i.e., greater than 0.33 pCi/m^3) were considered to be significant. Because results are reported to the nearest 0.1 pCi/m^3, a gross beta concentration equal to or greater than 0.4 pCi/m^3 was assumed to represent a departure from background.

Utilizing the Way-Wigner equation for long-lived gross beta activity in air, an estimate of the apparent fission product age was determined (*4*). Analysis of 10 randomly selected air filters indicated a time of formation not inconsistent with a November 18 detonation date

---

[1] National Environmental Research Center-Las Vegas, U.S. Environmental Protection Agency, Las Vegas, Nev. At the time this work was performed, the Center was named the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding No. AT(26–1)–539 with the Nevada Operations Office, U.S. Atomic Energy Commission. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

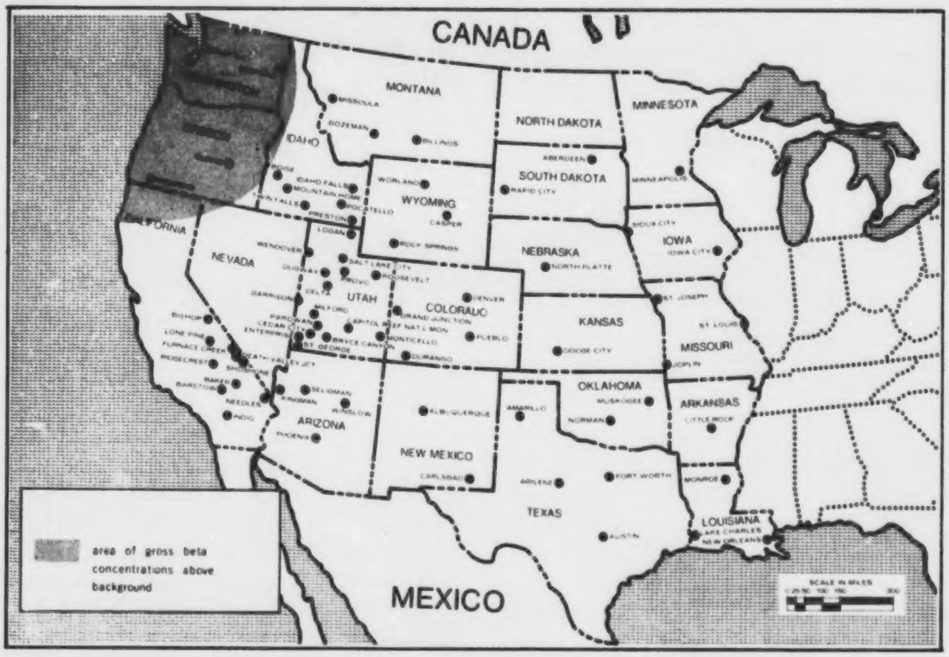
CANADA
MONTANA
NORTH DAKOTA
MINNESOTA
IDAHO
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MEXICO
CALIFORNIA
MISSOULA
BOZEMAN
BILLINGS
WORLAND
CASPER
ROCK SPRINGS
ABERDEEN
RAPID CITY
MINNEAPOLIS
NORTH PLATTE
SIOUX CITY
IOWA CITY
ST. JOSEPH
ST. LOUIS
DENVER
PUEBLO
GRAND JUNCTION
DURANGO
DODGE CITY
JOPLIN
MUSKOGEE
NORMAN
LITTLE ROCK
AMARILLO
ALBUQUERQUE
CARLSBAD
ABILENE
FORT WORTH
AUSTIN
MONROE
LAKE CHARLES
NEW ORLEANS
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
MILFORD
CEDAR CITY
ENTERPRISE
ST. GEORGE
BRYCE CANYON
CAPITOL REEF NAT'L MON
MONTICELLO
WENDOVER
LOGAN
PRESTON
POCATELLO
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
BOISE
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
BAKER
BARSTOW
NEEDLES
INDIO
DEATH VALLEY JCT
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
area of gross beta concentrations above background
SCALE IN MILES
0 25 50 100 150 300

Figure 1. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 26, 1971, 1200 local standard time

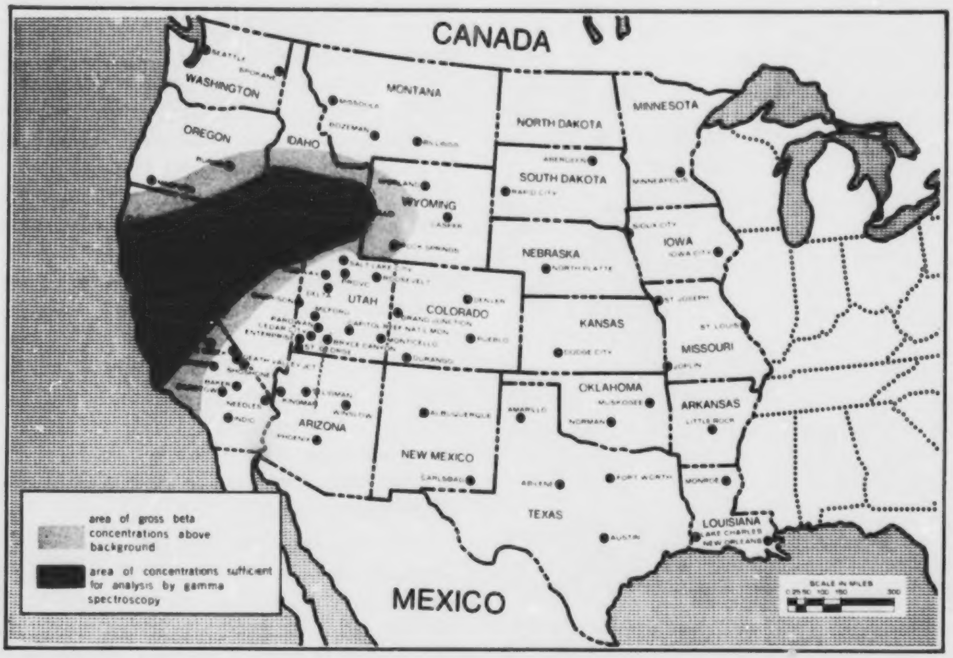
CANADA
SEATTLE
SPOKANE
WASHINGTON
OREGON
MONTANA
NORTH DAKOTA
MINNESOTA
IDAHO
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
UTAH
COLORADO
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MEXICO
MISSOULA
BOZEMAN
BILLINGS
CASPER
ROCK SPRINGS
ABERDEEN
RAPID CITY
MINNEAPOLIS
NORTH PLATTE
SIOUX CITY
IOWA CITY
ST. JOSEPH
ST. LOUIS
DENVER
PUEBLO
GRAND JUNCTION
DURANGO
DODGE CITY
JOPLIN
MUSKOGEE
NORMAN
LITTLE ROCK
AMARILLO
ALBUQUERQUE
CARLSBAD
ABILENE
FORT WORTH
AUSTIN
MONROE
LAKE CHARLES
NEW ORLEANS
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
MILFORD
CEDAR CITY
ENTERPRISE
ST. GEORGE
BRYCE CANYON
CAPITOL REEF NAT'L MON
MONTICELLO
DEATH VALLEY JCT
BAKER
NEEDLES
INDIO
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
area of gross beta concentrations above background
area of concentrations sufficient for analysis by gamma spectroscopy
SCALE IN MILES
0 25 50 100 150 300

Figure 2. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 25, 1971, 1200 local standard time

12

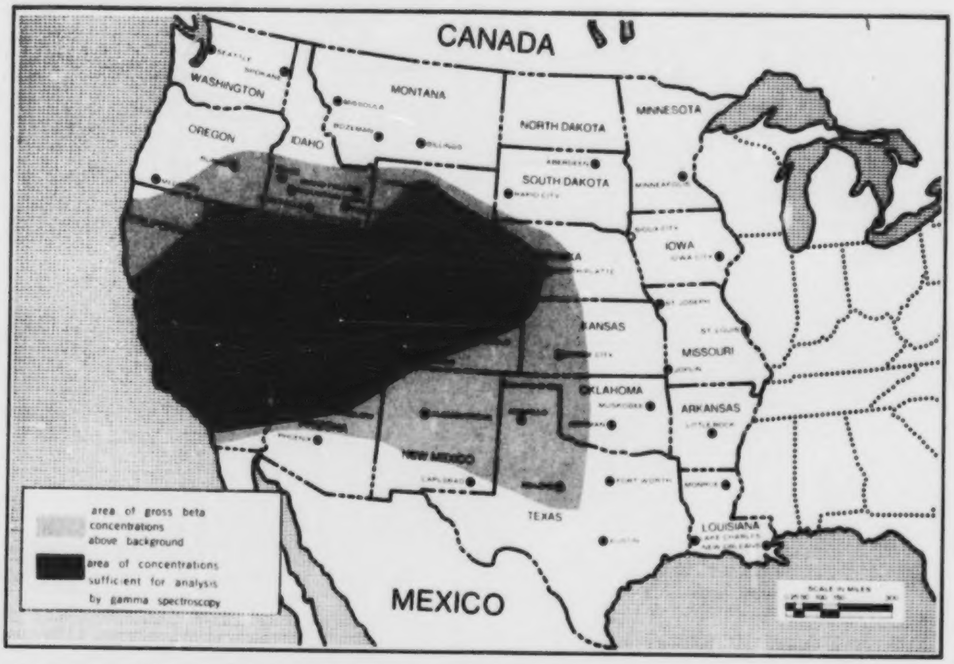
CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
IOWA
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
area of gross beta concentrations above background
area of concentrations sufficient for analysis by gamma spectroscopy
SCALE IN MILES

Figure 3. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 26, 1971, 1200 local standard time

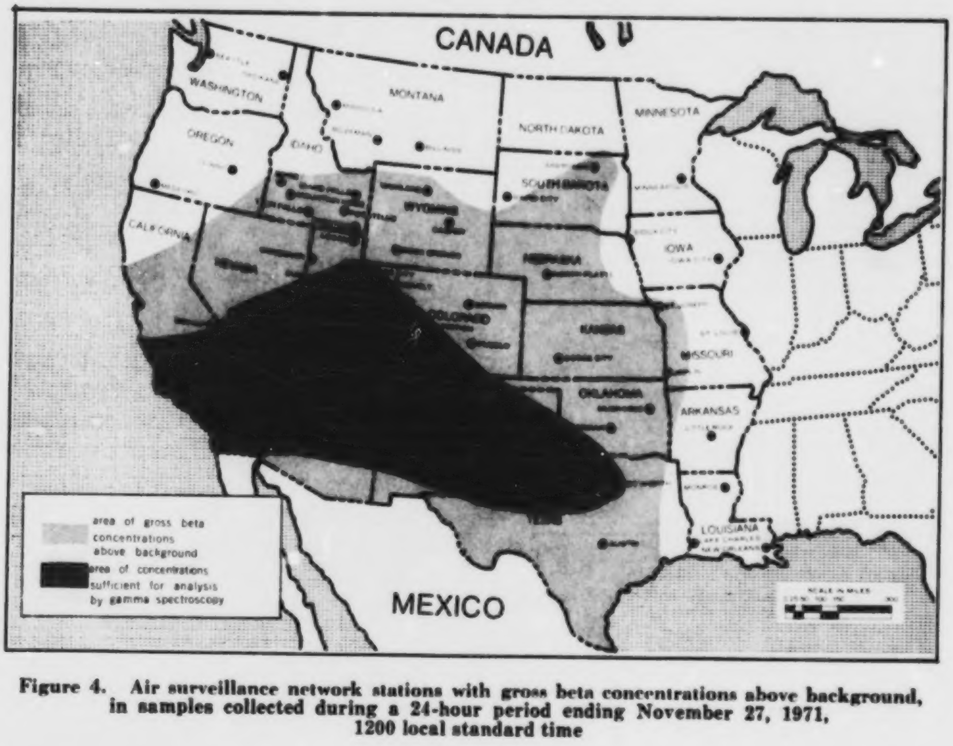
CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEVADA
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
LOUISIANA
MEXICO
area of gross beta concentrations above background
area of concentrations sufficient for analysis by gamma spectroscopy
SCALE IN MILES

Figure 4. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 27, 1971, 1200 local standard time

13

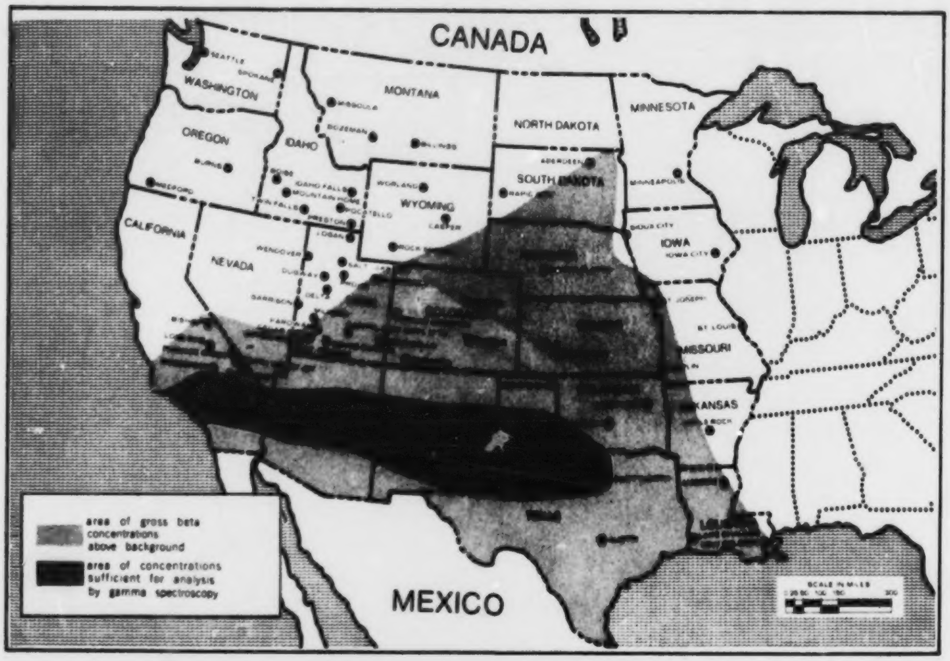
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
MINNESOTA
IOWA
CALIFORNIA
NEVADA
MISSOURI
ARKANSAS
MEXICO
area of gross beta concentrations above background
area of concentrations sufficient for analysis by gamma spectroscopy
SCALE IN MILES

Figure 5. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 28, 1971, 1200 local standard time

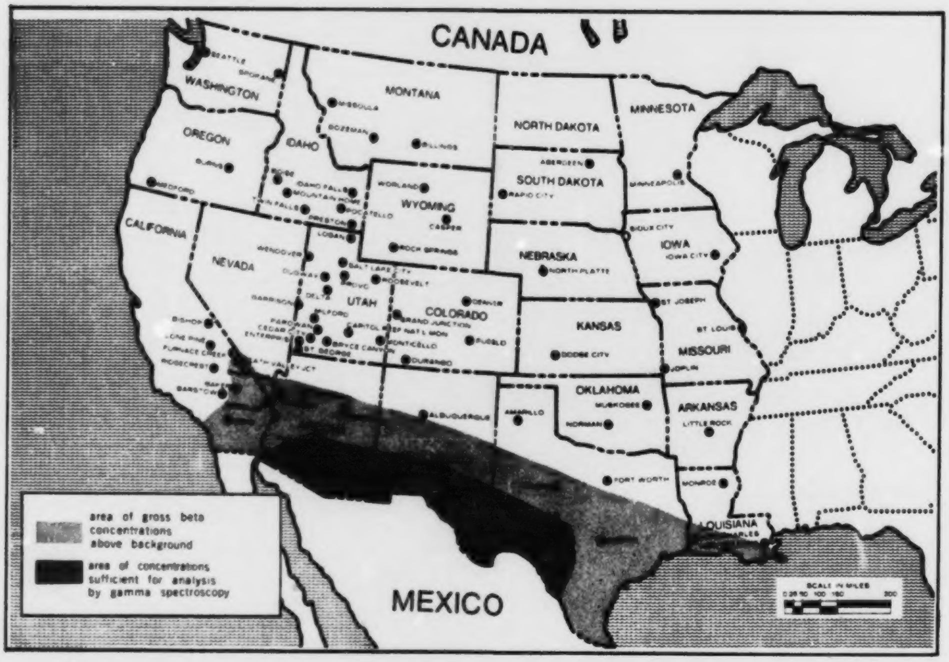
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
MINNESOTA
IOWA
NEBRASKA
CALIFORNIA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
LOUISIANA
MEXICO
area of gross beta concentrations above background
area of concentrations sufficient for analysis by gamma spectroscopy
SCALE IN MILES

Figure 6. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 29, 1971, 1200 local standard time

14

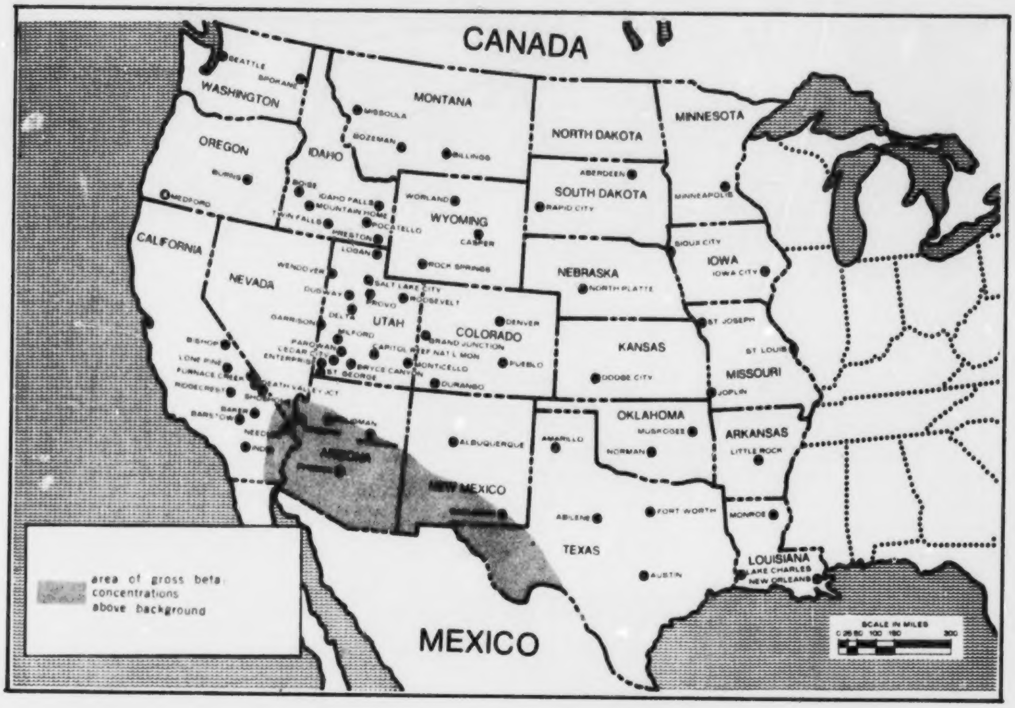
CANADA
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
OREGON
IDAHO
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEVADA
IOWA
NEBRASKA
UTAH
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
area of gross beta concentrations above background
SCALE IN MILES

Figure 7. Air surveillance network stations with gross beta concentrations above background, in samples collected during a 24-hour period ending November 30, 1971, 1200 local standard time

Gross beta air sampling results for successive days are plotted in figures 1 through 7. By December 1, gross beta concentrations at all stations had dropped to background.

Composition of airborne radioactivity

Gross beta concentrations above background were measurable at 95 routine ASN stations. A total of 83 stations showed concentrations high enough to allow quantitation of specific radionuclides by gamma spectroscopy. Radionuclides quantitated included cerium-141, barium-140, tellurium-132, and iodine-131. The highest single gross beta concentration was 51 pCi/m^3 observed on a prefilter collected at Fallon, Nev., on November 25. Analysis of this sample by gamma spectroscopy showed radionuclide concentrations as follows:

Iodine-131 = 2.0 pCi/m^3
Cerium-141 = .9 pCi/m^3
Barium-140 = 2.6 pCi/m^3
Tellurium-132 = 1.6 pCi/m^3

Uranium-237 was also present on the air filters analyzed in quantities approximately equal to that of barium-140. Additional trace radionuclides identified but not quantitated included molybdenum-99, zirconium-95, ruthenium-103, and neodymium-147.

Of the above radionuclides, only iodine-131 and tellurium-132 were considered to contribute to the hypothetical infant thyroid dose equivalents represented by figures 8 and 9. Hypothetical doses from other radionuclides were much smaller than the thyroid dose and were neglected.

Analysis of activated charcoal cartridges (secondary to the particulate filters) from 25 routine air sampling stations indicated that the airborne radioactivity was particulate in nature with little or no detectable gaseous radioiodine.

Hypothetical thyroid inhalation dose equivalents

Hypothetical thyroid dose equivalents corresponding to inhalation of airborne radio-

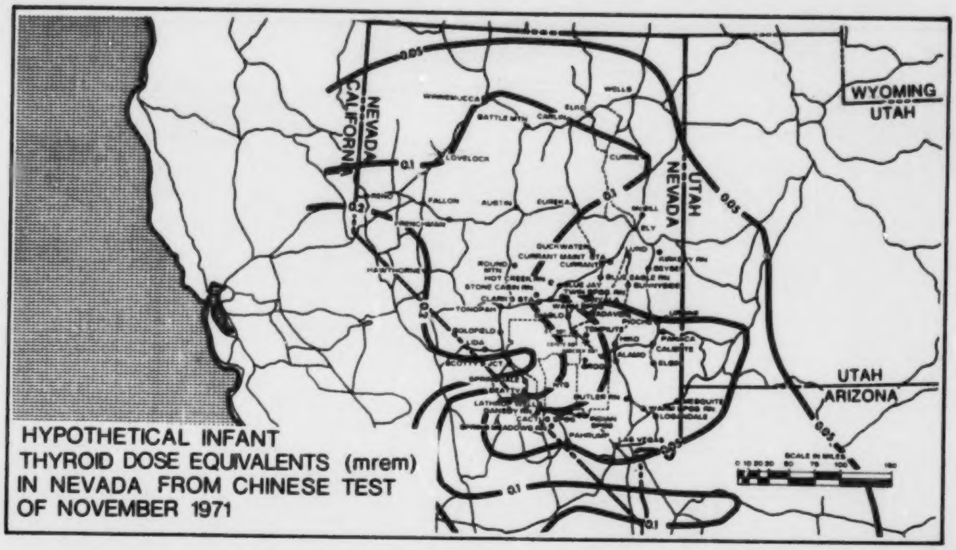
HYPOTHETICAL INFANT
THYROID DOSE EQUIVALENTS (mrem)
IN NEVADA FROM CHINESE TEST
OF NOVEMBER 1971
WYOMING
UTAH
NEVADA
CALIFORNIA
UTAH
NEVADA
UTAH
ARIZONA
0.05
0.1
0.2
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
FALLON
AUSTIN
EUREKA
ELY
HAWTHORNE
TONOPAH
GOLDFIELD
LAS VEGAS
SCALE IN MILES

Figure 8. Hypothetical infant thyroid dose equivalents (mrem) in Nevada from the Chinese test of November 1971

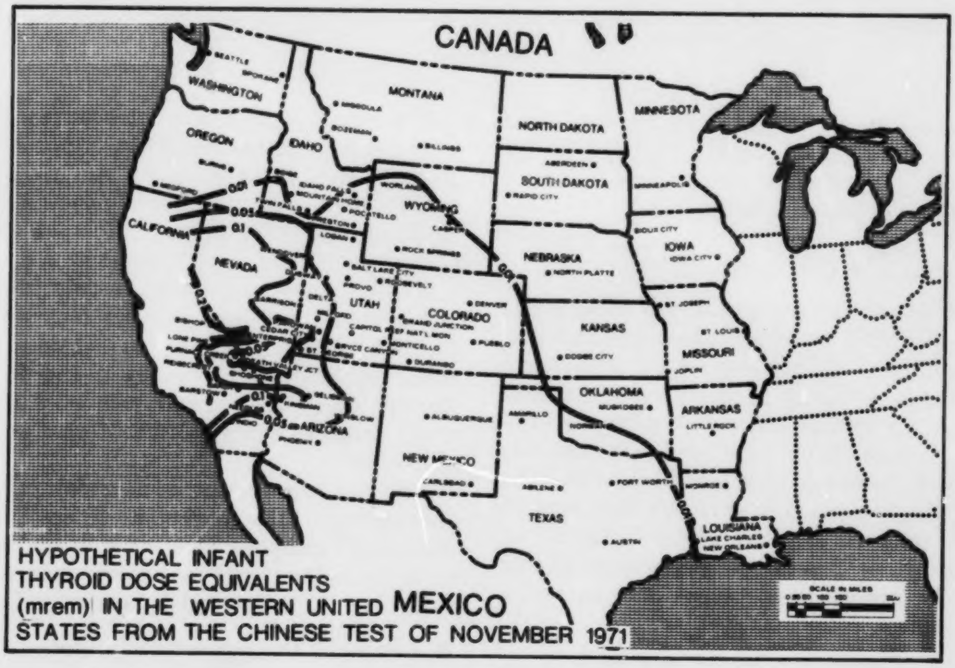
CANADA
WASHINGTON
SEATTLE
SPOKANE
OREGON
IDAHO
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNEAPOLIS
WYOMING
CASPER
ROCK SPRINGS
POCATELLO
IDAHO FALLS
TWIN FALLS
LOGAN
CALIFORNIA
NEVADA
UTAH
SALT LAKE CITY
PROVO
NEBRASKA
NORTH PLATTE
SIOUX CITY
IOWA
IOWA CITY
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
MONTICELLO
DURANGO
KANSAS
DODGE CITY
ST JOSEPH
ST LOUIS
MISSOURI
JOPLIN
OKLAHOMA
MUSKOGEE
ARKANSAS
LITTLE ROCK
ARIZONA
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
AMARILLO
ABILENE
FORT WORTH
TEXAS
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
0.01
0.05
0.1
HYPOTHETICAL INFANT
THYROID DOSE EQUIVALENTS
(mrem) IN THE WESTERN UNITED STATES FROM THE CHINESE TEST OF NOVEMBER 1971
MEXICO
SCALE IN MILES

Figure 9. Hypothetical infant thyroid dose equivalents (mrem) in the Western United States from the Chinese test of November 1971

activity were computed using measured time-integrated concentrations of iodine-131 and tellurium-132, and the following dose conversion factors:

Radionuclide	Dose conversion factor $\left(\frac{\text{mrem}}{\mu\text{Ci-s/m}^3}\right)$
Iodine-131	0.59
Tellurium-132	.12

These dose conversion factors were derived using the models and standard man assumptions of ICRP Publications 2 and 10 (*5, 6*), an assumed thyroid weight for a 1-year-old infant of 2 grams (*7*), and an assumed infant breathing rate of 4.7 m^3/day (*8*). The dose from tellurium-132 was considered to result from uptake of the daughter iodine-132 into the blood stream and subsequently into the thyroid as described in ICRP 10. The computations are hypothetical in the sense that the critical receptor (a 1-year-old infant) was assumed to be present and continuously exposed to the airborne radioactivity at each location, whether or not this was actually the case.

Figures 8 and 9 show ASN sampling stations and the isodose patterns for hypothetical infant thyroid dose equivalents in Nevada and in the western United States, respectively. All locations identified by name on these two figures have ASN stations. The highest calculated infant dose equivalent, slightly more than 0.2 mrem, occurred at Scotty's Junction, Nev. The hypothetical adult dose equivalent at that location was approximately 0.1 mrem. Adult dose equivalents, calculated on the basis of a 20-gram thyroid weight and a breathing rate of 22.8 m^3/day (*8*), were approximately half of the levels shown in figures 8 and 9.

REFERENCES

(*1*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY, Air surveillance monthly report, November 1971. Radiat Data Rep 13:222–226 (April 1972).

(*2*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Special thyroid inhalation dose report, NERC–LV. (November 1971).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washingtonton, D.C. 20402 (September 1961).

(*4*) WAY, K. and E. P. WIGNER. The rate of decay of fission products. Phys. Rev. 731318–1330 (June 1948).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation, ICRP Publication 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, ICRP Publication 10. A report of Committee IV on evaluation of radiation doses to body tissues from internal contamination due to occupational exposure. Pergamon Press, New York, N.Y. (1968).

(*7*) BRYANT, P. M. Data for assessments concerning controlled and accidental releases of ^{131}I and ^{137}Cs to the atmosphere. Health Phys 17:51 (July 1969).

(*8*) U.S. PUBLIC HEALTH SERVICE. Radiological Health Handbook. (January 1970) pp. 215–217.

Data

SECTION I. MILK AND FOOD

Milk Surveillance, September 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentration and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

18

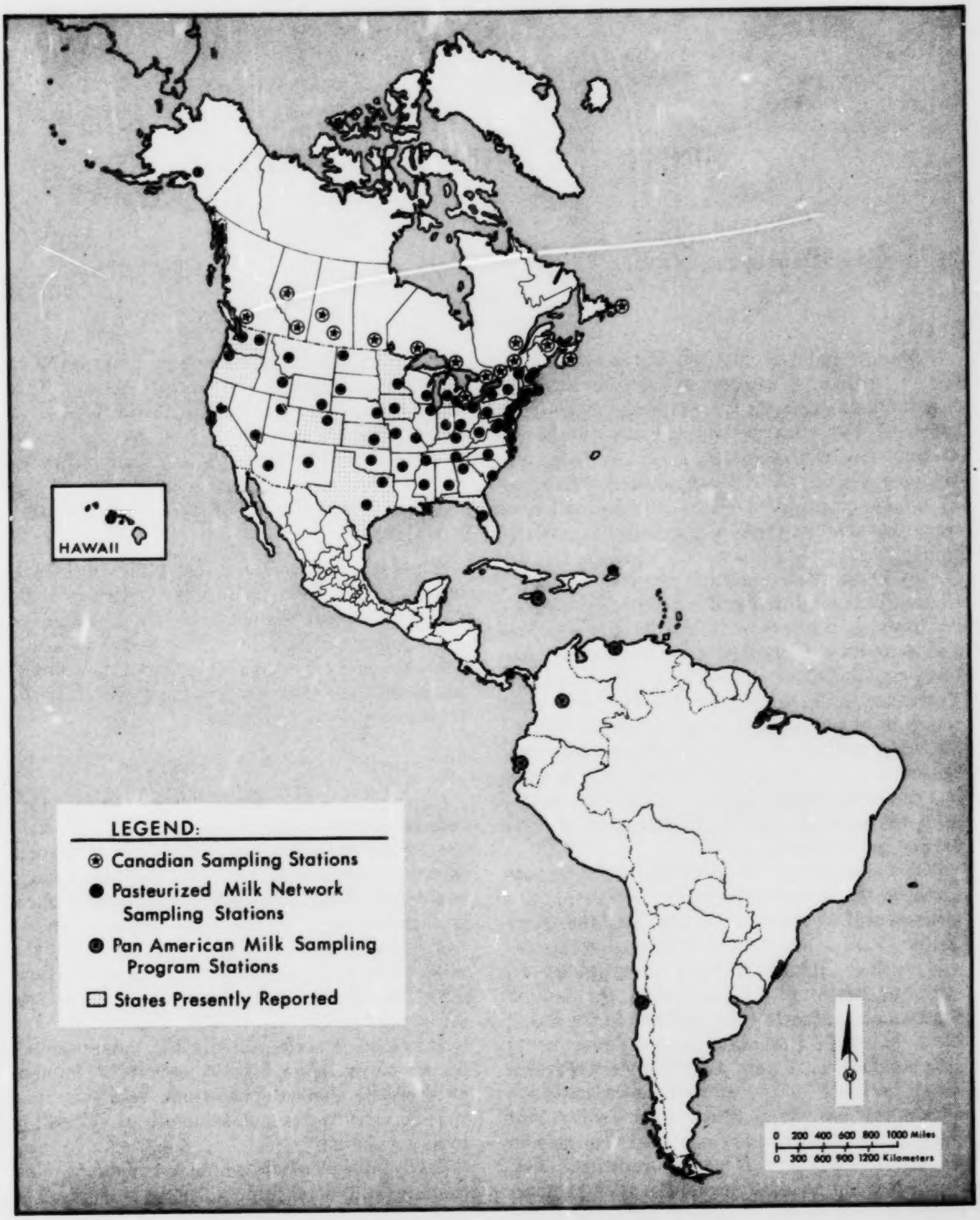
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
◉ Pan American Milk Sampling Program Stations
☐ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable[a]	Warning level[b]	Unacceptable[c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data [illegible]ion. Current levels for strontium-9[illegible]137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports*.

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:						
Ala:	Montgomery[c]	P	NA	7	0	6
Alaska:	Palmer[c]	P	5	5	0	9
Ariz:	Phoenix[c]	P	NA	0	0	0
Ark:	Little Rock[c]	P	NA	11	0	7
Calif:	Sacramento[c]	P	NA	1	0	0
	San Francisco[c]	P	NA	1	0	0
	Del Norte	P	9	12	0	11
	Fresno	P	0	2	0	5
	Humboldt	P	3	4	0	8
	Los Angeles	P	0	2	0	4
	Mendocino	P	0	5	0	6
	Sacramento	P	0	2	0	5
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	6
	Shasta	P	0	3	0	7
	Sonoma	P	0	2	0	6
Colo:	Denver[c]	P	NA	5	0	4
	East	R	NS	NA	NS	0
	Northeast	R	NA	NA	[d]0 (21)	0
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NA	NA	[d]0	0
	West	R	NS	NA	NS	4
Conn:	Hartford[c]	P	NA	6	0	7
	Central	P	6	7	11	13
Del:	Wilmington[c]	P	NA	8	0	7
D.C:	Washington[c]	P	NA	7	0	6
Fla:	Tampa[c]	P	7	5	33	39
	Central	R	3	5	84	44
	North	R	4	8	15	18
	Northeast	R	5	6	38	34
	Southeast	R	5	6	23	56
	Tampa Bay area	P	5	5	39	37
	West	R	7	9	0	15
Ga:	Atlanta[c]	P	8	9	7 (2)	11
Hawaii:	Honolulu[c]	P	3	3	0	1
Idaho:	Idaho Falls[c]	P	3	4	0	0
Ill:	Chicago[c]	P	4	6	0	9
Ind:	Indianapolis[c]	P	NA	6	0	2
	Central	P	10	7	0	10
	Northeast	P	5	7	0	12
	Northwest	P	8	8	10	12
	Southeast	P	7	8	16	12
	Southwest	R	7	8	10	12
Iowa:	Des Moines[c]	P	NA	4	0	1
	Iowa City	P	7	6	16	9
	Des Moines	P	5	6	0	9
	Little Cedar	P	NS	6	NS	10
	Spencer	P	5	7	11	12
Kans:	Wichita[c]	P	NA	8	0	1
	Coffeyville	P	6	7	0	10
	Dodge City	P	6	5	0	8
	Falls City, Nebr	R	8	3	0	8
	Hays	P	7	9	0	9
	Kansas City	P	7	8	0	11
	Topeka	P	6	7	11	9
	Wichita	P	9	9	0	8
Ky:	Louisville[c]	P	NA	8	0	6
La:	New Orleans[c]	P	12	13	0	6
Maine:	Portland[c]	P	NA	6	21	19
Md:	Baltimore[c]	P	NA	7	13	4
Mass:	Boston[c]	P	6	7	15	10
Mich:	Detroit[c]	P	NA	7	15	8
	Grand Rapids[c]	P	NA	7	0	7
	Bay City	P	6	5	0	10
	Charlevoix	P	5 (3)	7	0 (3)	12
	Detroit	P	3	5	13	9
	Grand Rapids	P	4	5	0	7
	Lansing	P	0	6	11	11
	Marquette	P	3	6	14	20
	Monroe	P	NA	3	NA	4
	South Haven	P	3 (3)	5	0 (3)	7
Minn:	Minneapolis[c]	P	NA	8	12	16
	Bemidji	P	5	7	20	18
	Duluth	P	16	15	37	27
	Fergus Falls	P	8	8	11	15
	Little Falls	P	20	18	44	40
	Mankato	P	NS	5	NS	11
	Marshall	P	6	[illegible]	0	11

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972—continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—continued						
Minn:	Minneapolis	P	9	18	0	15
	Rochester	P	5	7	0	12
Miss:	Jackson[c]	P	NA	10	0	7
Mo:	Kansas City[c]	P	NA	7	0	3
	St. Louis[c]	P	NA	7	0	8
Mont:	Helena[c]	P	NA	5	0	4
Nebr:	Omaha[c]	P	NA	5	0	1
Nev:	Las Vegas[c]	P	NA	2	0	0
N.H:	Manchester[c]	P	NA	8	19	17
N.J:	Trenton[c]	P	NA	7	15	6
N. Mex:	Albuquerque[c]	P	NA	2	0	0
N.Y:	Buffalo[c]	P	4	6	0	5
	New York City[c]	P	NA	8	0	8
	Syracuse[c]	P	NA	7	0	6
	Albany	P	5 (3)	7	0 (4)	0
	Buffalo	P	NS	NS	0	0
	Massena	P	NS	NS	19	0
	New York City	P	7	7	11	0
	Syracuse	P	NS	NS	0	0
N.C:	Charlotte[c]	P	NA	10	13	8
N. Dak:	Minot[c]	P	NA	9	0	11
Ohio:	Cincinnati[c]	P	NA	7	0	3
	Cleveland[c]	P	NA	6	19	8
Okla:	Oklahoma City[c]	P	NA	6	0	6
Oreg:	Portland[c]	P	4	5	0	3
	Baker	P	NA		12	1
	Coos Bay	P	NA		21	2
	Eugene	P	NA		0	1
	Medford	P	NA		17	4
	Portland composite	P	NA		15	6
	Portland local	P	NA		14	5
	Redmond	P	NA		0	0
	Tillamook	P	NA		0	11
Pa:	Philadelphia[c]	P	NA	7	0	3
	Pittsburgh[c]	P	NA	9	0	5
	Dauphin	P	5	7	0	11
	Erie	P	7	7	11	12
	Philadelphia	P	5	5	0	10
	Pittsburgh	P	8	7	0	14
R.I:	Providence[c]	P	NA	6	15	11
S.C:	Charleston[c]	P	7	9	11	13
S. Dak:	Rapid City[c]	P	NA	7	0	3
Tenn:	Chattanooga[c]	P	NA	8	0	8
	Memphis[c]	P	NA	7	11	3
	Chattanooga	P	10	10	11	13
	Clinton	R	13	10	19	14
	Fayetteville	R	10	10	0 (2)	6
	Kingston	R	8	9	0 (2)	7
	Knoxville	P	8	8	0 (2)	8
	Lawrenceburg	R	6	8	0	10
	Nashville	P	10	8	0 (2)	6
	Pulaski	R	7	7	0 (2)	8
Tex:	Austin[c]	P	NA	3	0	0
	Dallas[c]	P	NA	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City[c]	P	0	3	0	3
Vt:	Burlington[c]	P	NA	6	0	9
Va:	Norfolk[c]	P	NA	8	0	6
Wash:	Seattle[c]	P	NA	5	15	5
	Spokane[c]	P	NA	5	0	7
	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	2
	Longview	R	3	3	0	0
	Sandpoint, Idaho	R	4	10	0	15
	Skagit County	R	7	7	13	5
W. Va:	Charleston[c]	P	NA	8	0	5
Wisc:	Milwaukee[c]	P	NA	5	12	6
Wyo:	Laramie[c]	P	NA	4	0	2

See footnotes at end of table.

23

Table 2. Concentrations of radionuclides in milk for September 1972 and 12-month period October 1971 through September 1972—continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA:					
Alberta: Calgary	P	6	7	16	19
Edmonton	P	8	7	13	25
British Columbia:					
Vancouver	P	9	8	16	23
Manitoba: Winnipeg	P	5	6	0	20
New Brunswick:					
Fredericton	P	NA	NA	NA	NA
Newfoundland:					
St. John's	P	28	19	31	26
Nova Scotia:					
Halifax	P	8	9	0	19
Ontario: Ottawa	P	6	6	0	11
Sault Ste. Marie	P	10	11	25	26
Thunder Bay	P	10	10	20	22
Toronto	P	2	3	0	10
Windsor	P	3	3	0	8
Quebec: Montreal	P	6	6	0	14
Quebec	P	9	9	12	25
Saskatchewan:					
Regina	P	6	7	0	16
Saskatoon	P	6	7	0	15
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal[c]	P	NA	1	36	12
Chile: Santiago	P	1	1	0	1
Colombia: Bogota	P	1	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Montego Bay	P	2	2	110	52
Puerto Rico:					
San Juan[c]	P	NA	3	0	5
Venezuela:					
Caracas	P	0	0	0	0
PMN network average[e]		5	6	4	6

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter
Oregon—15 pCi/liter

[e] This entry gives the average radionuclide concentration for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply; the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for September 1972 and the 12-month period, October 1971 to September 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131,

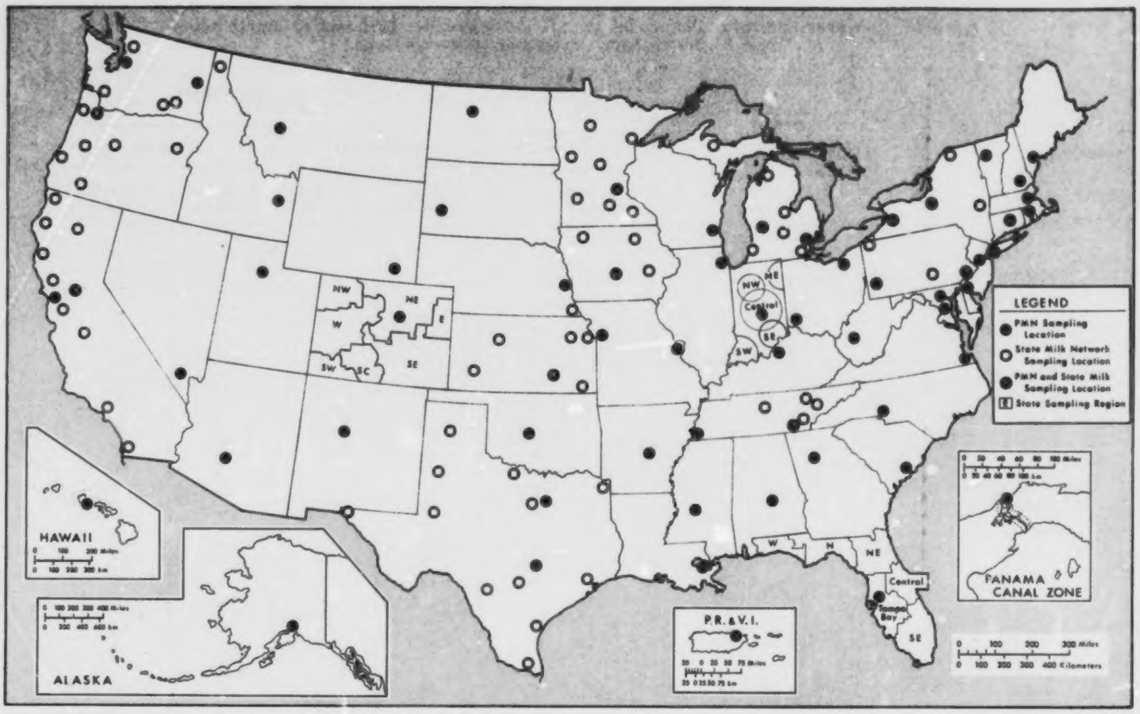
LEGEND
● PMN Sampling Location
○ State Milk Network Sampling Location
● PMN and State Milk Sampling Location
E State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R. & V.I.
PANAMA CANAL ZONE
0 100 200 300 Miles
0 100 200 300 400 Kilometers

Figure 2. State and PMN milk sampling stations in the United States

and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for September 1972 were below the respective reporting levels. Table 3 gives monthly average for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for September 1972, and the highest 12-month average was 18 pCi/liter (Little Falls and Minneapolis, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 84 pCi/liter in the United States for September 1972, and the highest 12-month average was 56 pCi/liter (Southeast Florida) representing 1.6 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (7) and Jamaica.

Table 3. Strontium-89, iodine-131, and barium-140 in milk,[1] September 1972

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Barium-140
United States:			
Colo:	Southwest		28
N.Y:	Albany	6	
Canada:			
Alberta:	Edmonton	7	
British Columbia:	Vancouver	7	
Manitoba:	Winnipeg	6	
Nova Scotia:	Halifax	6	
Quebec:	Quebec	8	
Saskatchewan:	Saskatoon	6	

[1] No iodine-131 detected.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer
  Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National
  Health and Welfare

Radiological Health Section
Division of Occupational and
  Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational
  Health Section
Department of Health and
  Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of
  Environmental Conservation

Environmental Radiation Surveillance
  Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of
  Social and Health Services

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium-89 and strontium-90 measurements in milk, July 1971, Technical experiment 71–MKAQ–1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1971).

(6) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(7) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1971	December 1972
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	November 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium-90 in Tri-City Diets	January-December 1971	December 1972

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1970	December 1971
Michigan	January-June 1970	November 1971
Minnesota Municipal Water	July-1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radiostrontium in Tap Water, *HASL*	July-December 1971	November 1972
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs, *NERC–LV*	January-March 1972	December 1972

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards. Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards. Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States May 1972

Office of Water Planning and Standards
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1967 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Planning and Standards. Regional offices of the Environmental Protection Agency are responsible for the collection and retrieval system. Radioactivity analyses are performed in the centralized laboratories of the Office of Water Planning and Standards (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Table 1 presents the gross alpha and beta radioactivity results for samples collected from 11 rivers during May 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are collected for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

Table 2 presents the strontium-90 results on samples collected and composited from 27 rivers during the third quarter of the 1971 water year (April-June 1971). The analytical procedures used for determining strontium-90 are described in *Radionuclide Analysis of Environmental Samples* (*2*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards Handbook 85 (*3*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION: AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

(*3*) U.S. DEPARTMENT OF COMMERCE. Physical Aspects of Irradiation, Recommendation of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 85, (March 31, 1964).

Table 1. Gross radioactivity in U.S. surface waters, May 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn	3	<0.4	<0.5	2	6
		<.4	.6	2	6
		<.3	<.4	3	5
Colorado River:					
Colorado-Utah State line	1	7.7	1.9	30	11
DeBeque, Colo	1	<1.0	<1.5	11	11
Grand Junction, Colo	1	<2.0	2.5	20	15
Lee's Ferry, Ariz	1	<.3	5.2	3	18
Silt, Colo	1	1.4	4.2	5	11
Moab, Utah:					
Highway bridge	3	5.1	4.5	11	9
		4.3	2.8	15	8
		8.1	10.8	32	11
Above Mill Creek	4	5.8	3.8	13	8
		3.6	5.8	16	9
		16.2	22.7	35	22
		11.9	4.1	31	13
Dolores River:					
Bedrock, Colo	4	1.3	2.0	6	16
		1.5	2.5	7	11
		7.7	.7	22	2
		1.0	1.7	6	6
Gateway, Colo	4	.6	5.8	6	39
		2.8	25.1	8	31
		6.0	3.0	21	8
		4.2	5.1	19	30
Green River:					
Greendale, Utah	1	<.3	3.4	3	15
Mississippi River:					
Burlington, Iowa	1	3.9	2.4	7	7
Dubuque, Iowa	1	2.5	2.1	7	7
Missouri River:					
St. Joseph, Mo	1	12.5	<1.2	47	15
St. Louis, Mo	1	18.5	<1.2	45	14
Ohio River:					
Cincinnati, Ohio	3	<.6	<.7	6	5
		4.4	.9	13	5
		.3	.6	3	5
Roanoke River:					
John Kerr Dam, Va	3	<.3	<.6	3	4
		<.4	<.3	<2	4
		<.4	<.4	<2	3
San Miguel River:					
Uravan, Colo	3	1.9	5.7	6	11
		<.2	<2.0	3	11
		1.1	2.3	9	11
Below Uravan, Colo	4	3.4	20.0	5	14
		2.5	2.3	9	14
		<.5	11.7	11	18
		<.4	23.5	2	21
Naturita, Colo	4	1.0	<.9	<2	<2
		<.4	<1.5	3	8
		<.5	<1.1	6	6
		1.5	<.7	8	5
St. Lawrence River:					
Massena, N.Y	4	<.4	<.7	<2	3
		<.4	<.7	<2	4
		.6	.7	3	6
		<.3	<.5	2	6
Yampa River:					
Maybell, Colo	1	1.7	<.6	4	5

30

Table 2. Radioactivity in surface waters, April–June 1971

River and location	Strontium-90 (pCi/liter)
Allegheny River:	
Pittsburgh, Pa	1.4
Beaver River:	
New Brighton, Pa	1.6
Big Sandy River:	
Wayne County, W. Va	1.0
Big Sioux River:	
Brandon, S. Dak	3.6
Clinch River:	
Kingston, Tenn	2.3
Cheyenne River:	
Edgemont, S. Dak	2.8
Great Miami River:	
American Material Bridge, Hamilton, Ohio	<.5
Liberty-Fairfield, Ohio	.9
Lost Bridge, Ohio	.9
Sellars Road Bridge, Hamilton, Ohio	1.5
Guyandotte River:	
Guyandotte, W. Va	<.5
Kanawha River:	
Mason County, W. Va	.7
Winfield Dam, W. Va	.8
Kentucky River:	
Dam No. 1	.7
Licking River:	
Covington, Ky	1.1
Little Miami River:	
Cincinnati, Ohio	1.3
Maumee River:	
Toledo, Ohio	1.2
Mississippi River:	
Burlington, Iowa	1.9
Missouri River:	
Bismarck, N. Dak	2.8
St. Joseph, Mo	1.9
St. Louis, Mo	2.0
Monongahela River:	
Pittsburgh, Pa	1.9
Muskingum River:	
Dam No. 2, Mich	2.3
Ohio River:	
Addison, Ohio	1.6
Ashland, Ky	2.8
Eldean Mills, Ohio	1.6
Hancock, W. Va	1.3
Ironton, Ohio	1.7
Kyger Creek, W. Va	.8
Madison, Ind	1.8
Markland Dam, Ind	.8
Maysville, Ky	1.8
New Martinsville, Ohio	2.6
Portsmouth, Ohio	1.4
South Heights, Pa	1.3
Above Muskingum River, Ohio	1.6
Warwood, W. Va	1.7
Platte River:	
Plattsmouth, Nebr	1.5
Rainy River:	
International Falls, Minn	2.9
Roanoke River:	
John Kerr Dam, Va	.8
Sabine River:	
Rulyt, Tex	1.9
St. Lawrence River:	
Massena, N.Y	1.9
Susquehanna River:	
Conowingo Dam, Md	1.6
Holtwood, Pa	2.7
Whitewater River: (Ohio)	
Suspension Bridge	1.8
Yazoo River:	
Vicksburg, Miss	1.0
Yellowstone River:	
Sidney, Mont	2.2

31

Trituim Surveillance System, April-June 1972

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964, to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for the period January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for the period July-December 1969, have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 drinking water samples collected quarterly at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and samples collected quarterly at 39 surface water stations (figure 2). The specific locations for the surface water sampling system were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Laboratory or the National Environmental Research Center—Las Vegas for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

32

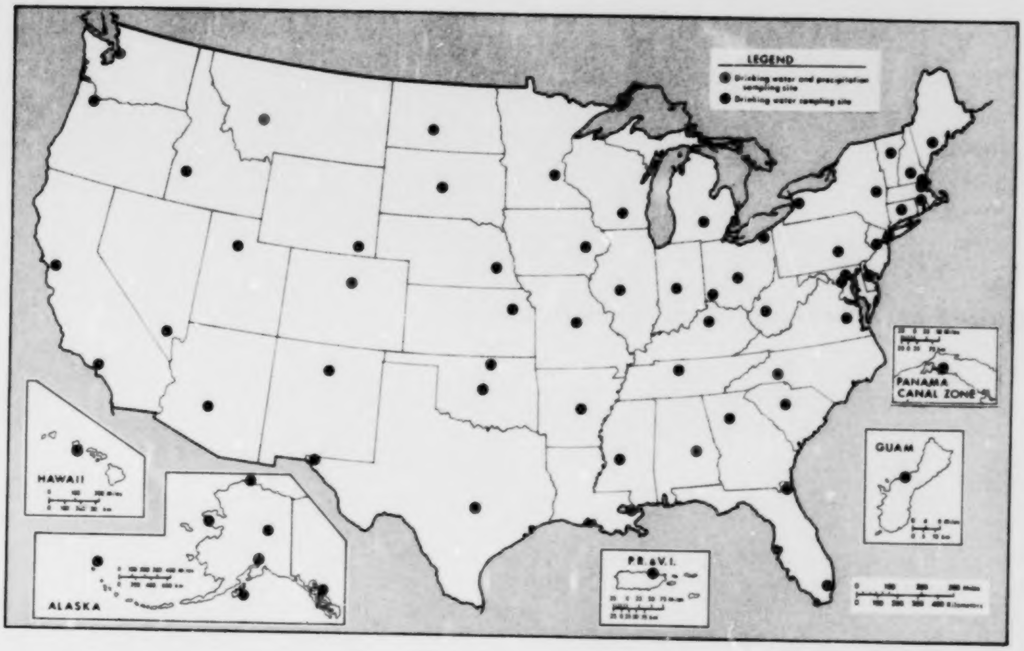
LEGEND
● Drinking water and precipitation sampling site
● Drinking water sampling site
PANAMA CANAL ZONE
GUAM
HAWAII
ALASKA
P.R. & V.I.

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

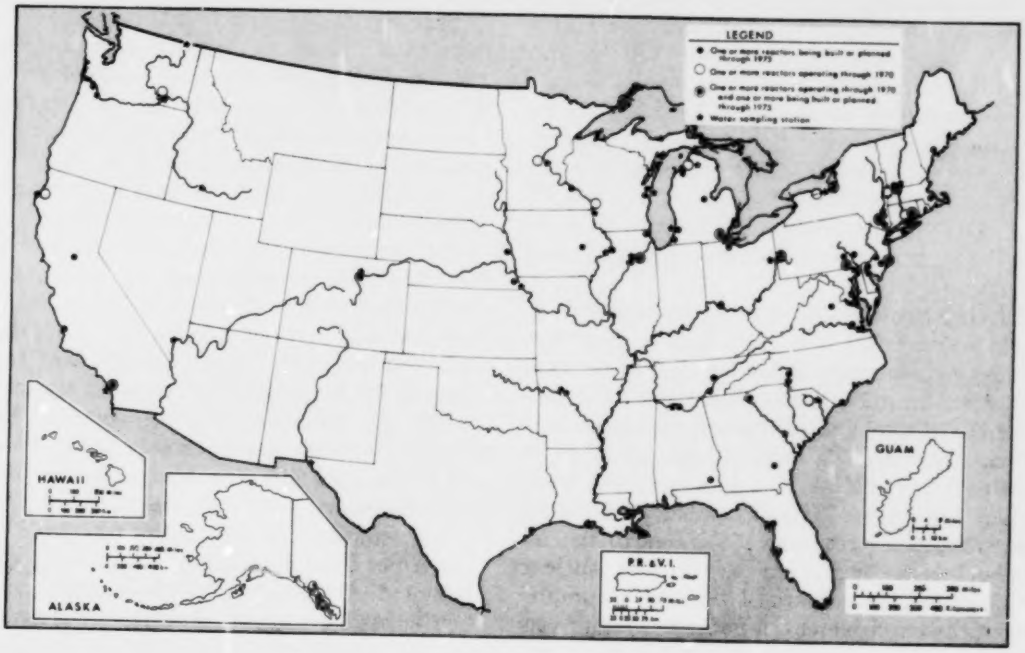
LEGEND
● One or more reactors being built or planned through 1975
○ One or more reactors operating through 1970
● One or more reactors operating through 1970 and one or more being built or planned through 1975
● Water sampling station
GUAM
HAWAII
ALASKA
P.R. & V.I.

Figure 2. Surface water sampling locations for tritium surveillance system

33

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for April-June 1972. The average tritium concentration was 0.4 nCi/liter.

Previous articles on the Tritium Surveillance System have reported dose equivalents from tritium in body water based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (*6*) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$H \text{ (mrem/year)} = 0.1C \text{ (nCi/liter)}$$

Where H is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

The highest individual concentration of tritium observed in the drinking water was 1.8 nCi/liter during the second quarter. This corresponds to a dose of 0.18 mrem/a, or less than 0.11 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 5.2 nCi/liter for the second quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.52 mrem/a, or 0.31 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 1. Tritium concentration in tap water (RAN stations) April–June 1972

Location		Date collected (1972)	Tritium concentration[a] (nCi/liter ± 2σ)[b]
Ala:	Montgomery	4/4	0.2
Alaska:	Anchorage	4/4	1.0
	Attu Island	NS	
	Fairbanks	NS	
	Juneau	4/3	.5
	Kodiak	NS	
	Nome	4/21	.8
	Point Barrow	4/1	1.3
Ariz:	Phoenix	4/3	.4
Ark:	Little Rock	4/5	0
Calif:	Berkeley	4/3	.5
	Los Angeles	4/6	.4
C.Z:	Ancon	4/25	0
Colo:	Denver	4/4	.6
Conn:	Hartford	4/12	.3
Del:	Dover	4/10	0
D.C:	Washington	4/28	0
Fla:	Jacksonville	4/5	0
	Miami	4/5	0
Ga:	Atlanta	4/4	.2
Guam:	Agana	4/4	0
Hawaii:	Honolulu	4/3	0
Idaho:	Boise	NS	
Ill:	Springfield	4/7	.4
Ind:	Indianapolis	4/5	.4
Iowa:	Iowa City	4/4	.5
Kans:	Topeka	4/14	.4
Ky:	Frankfort	4/10	.3
La:	New Orleans	4/3	.5
Maine:	Augusta	4/7	.4
Md:	Baltimore	4/6	.3
Mass:	Lawrence	4/11	.2
	Winchester	4/7	.4
Mich:	Lansing	4/6	0
Minn:	Minneapolis	4/11	.5
Miss:	Jackson	4/3	0
Mo:	Jefferson City	4/3	0
Mont:	Helena	4/3	.9
Nebr:	Lincoln	4/3	.5
Nev:	Las Vegas	4/10	1.0
N.H:	Concord	4/10	.2
N.J:	Trenton	4/7	.3
N. Mex:	Sante Fe	4/19	1.7 ±0.3
N.Y:	Albany	4/10	.3
	Buffalo	NS	
	New York City	4/15	.4
N.C:	Gastonia	4/6	.2
N. Dak:	Bismarck	4/11	1.3
Ohio:	Cincinnati	4/6	.4
	Columbus	4/10	.4
	Painesville	4/10	.4
Okla:	Oklahoma City	4/3	.3
	Ponca City	4/5	.4
Oreg:	Portland	4/3	0
Pa:	Harrisburg	4/12	.5
P.R:	San Juan	4/24	0
R.I:	Providence	4/18	.2
S.C:	Columbia	4/3	.4
S. Dak:	Pierre	4/3	1.8 ± .3
Tenn:	Nashville	4/4	.4
Tex:	Austin	4/10	0
	El Paso	4/4	.3
Utah:	Salt Lake City	4/7	.3
Vt:	Barre	4/10	.3
Va:	Richmond	4/6	.2
Wash:	Seattle	4/5	.2
	Spokane	4/3	.5
W. Va:	Charleston	4/7	.3
Wisc:	Madison	4/7	0
Wyo:	Cheyenne	4/27	1.0
Average			0.4

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

Table 2. Tritium concentration in surface water, April–June 1972

Location		Water source	Facility	Collection date (1972)	Concentration[a] (nCi/liter $\pm 2\sigma$)[b]
Ala:	Decatur	Tennessee River	Browns Ferry	[c]3/28	0.4
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	4/12	.6
Calif:	Eureka	Humboldt Bay	Humboldt Bay	4/24	0
	San Onofre	Pacific Ocean	San Onofre	4/10	0
Colo:	Greely	South Platte River	Fort St. Vrain	4/4	1.2
Conn:	East Haddam	Connecticut River	Connecticut Yankee and Vermont Yankee	4/12	.4
	Waterford	Long Island Sound	Millstone	4/19	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	4/14	0
	Homestead	Biscayne Bay	Turkey Point	5/18	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	4/3	.7
Ill:	Moline	Mississippi River	Quad-Cities	4/20	.4
	Morris	Illinois River	Dresden and Argonne	4/22	.3
La:	New Orleans	Mississippi River	(Several)	4/3	.4
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	4/27	.3
	Lusby	Chesapeake Bay	Calvert Cliffs	4/20	.2
Mass:	Rowe	Deerfield River	Yankee	4/20	.3
Mich:	Charlevoix	Lake Michigan	Big Rock Point	4/16	.4
	Monroe	Lake Erie	Enrico Fermi	4/10	.5
	South Haven	Lake Michigan	Palisades	4/6	.3
Minn:	Monticello	Mississippi River	Monticello	4/11	.7
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	4/5	1.1
Nev:	Boulder City	Colorado River	Background	4/13	1.4
N.J:	Bayside	Delaware River	Salem	4/25	.2
N.Y:	Ossining	Hudson River	Indian Point	4/17	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	4/11	.4
	Poughkeepsie	Hudson River	Background	4/12	.3
N.C:	Charlotte	Catawba River	Wm. B. McGuire	NS	
Oreg:	Westport	Columbia River	Rainier and Hanford	5/25	0.7
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	4/5	.4
	Hartsville	Lake Robinson	H. B. Robinson	4/18	1.6
Tenn:	Kingston	Clinch River	Oak Ridge	4/3	5.2
Tex:	El Paso	Rio Grande	Los Alamos	4/4	.4
Vt:	Vernon	Connecticut River	Vermont Yankee	4/7	.3
Va:	Newport News	James River	Surry	4/4	.3
Wash:	Northport	Columbia River	Background	4/26	.9
	Pasco	Columbia River	Hanford	4/5	.9
W. Va:	Wheeling	Ohio River	Shippingport	4/4	.4
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	4/17	.3
	Victory	Mississippi River	LaCrosse and Prairie Island	4/14	.4
Average					0.6

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

[c] Sample collected early.

NS, no sample.

Table 3. Tritium concentration in precipitation from RAN stations, April–June 1972

Location		Tritium concentration[a] (nCi/liter $\pm 2\sigma$)		
		April	May	June
Ala:	Montgomery	0.6	0.4	0.5
Alaska:	Anchorage	.3	.4	.4
Colo:	Denver	.4	.6	.6
Hawaii:	Honolulu	0	NS	0
La:	New Orleans	0	0	0
N.C:	Gastonia	0	.3	.5
Tex:	Austin	0	0	0
Wash:	Seattle	0	.3	.3

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

Other coverage in *Radiation Data and Reports:*

Period	Issue
April-June 1971	November 1971
July-September 1971	April 1972
October-December 1971	May 1972
January-March 1972	August 1972

REFERENCES

(*1*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638-639 (November 1970).

(*2*) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11:354-355 (July 1970).

(*3*) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9:337-339 (July 1968).

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(*5*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39, National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(*6*) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation Quantities and Units, ICRU Report No. 19, Washington, D.C. 20014 (July 1972).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports*.

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Surface Air Sampling Program 80th Meridian Network, *HASL*	January-December 1969	February 1972

36

1. Radiation Alert Network
September 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1972.

All field estimates reported were within normal limits for the reporting station.

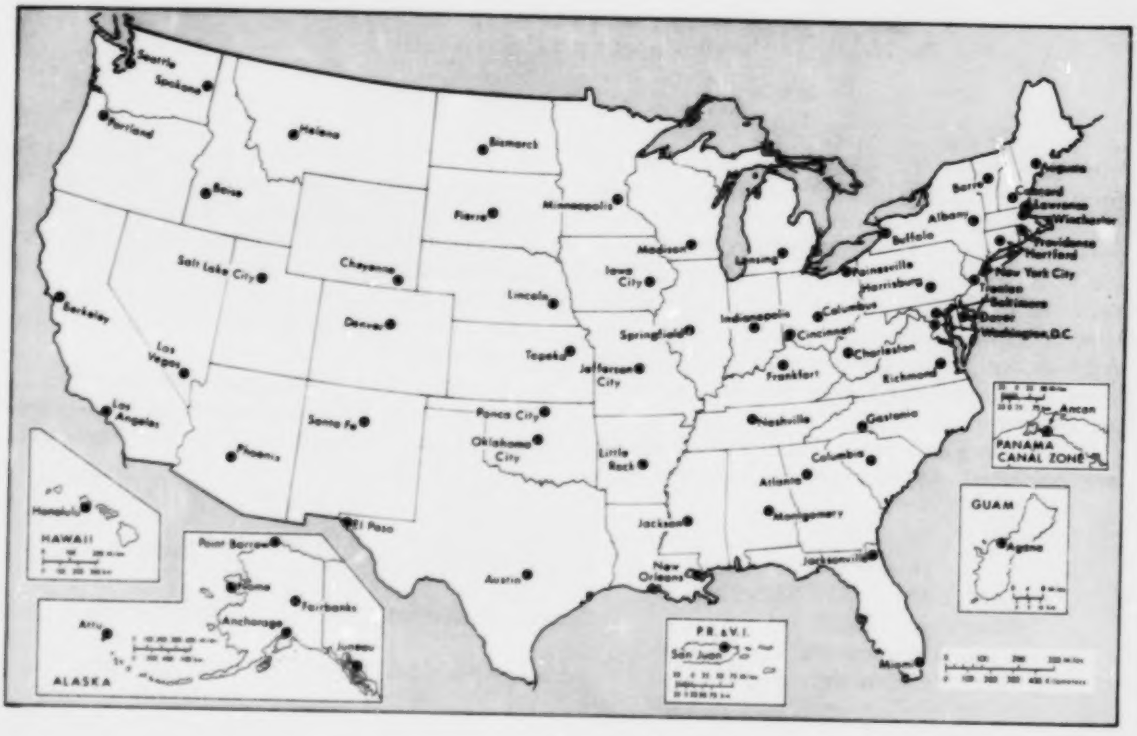
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Berkeley
Lincoln
Denver
Iowa City
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Indianapolis
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Springfield
Topeka
Jefferson City
Las Vegas
Los Angeles
Phoenix
Santa Fe
Ponca City
Oklahoma City
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Austin
El Paso
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Juneau
Attu
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m^3)			Precipitation				
						Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]			Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	16	2	0	1	3	51	3	51	7
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	30	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	19	10	1	4	0				
Ark:	Little Rock	20	3	0	1	0				
Calif:	Berkeley	20	1	0	0	2	31	2	31	0
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	15	0	0	0	0				
Colo:	Denver	20	8	1	3	4	20	(b)		
Conn:	Hartford	20	2	0	1	6	38	6	38	0
Del:	Dover	20	2	0	0	0				
D.C:	Washington	26	3	0	0	0				
Fla:	Jacksonville	20	2	0	0	4	179	3	170	10
	Miami	0				0				
Ga:	Atlanta	16	2	1	1	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	1	22	(b)		
Idaho:	Boise	19	2	0	1	4	15	4	15	5
Ill:	Springfield	0				0				
Ind:	Indianapolis	19	2	0	1	0				
Iowa:	Iowa City	19	2	0	1	6	59	6	59	3
Kans:	Topeka	19	3	1	1	3	49	3	49	1
Ky:	Frankfort	13	4	1	2	0				
La:	New Orleans	18	1	0	0	8	63	(b)		
Maine:	Augusta	16	2	0	1	4	90	4	90	0
Md:	Baltimore	19	3	0	1	3	23	3	23	0
Mass:	Lawrence	20	2	0	1	5	80	5	80	0
	Winchester	18	3	0	1	6	75	6	75	0
Mich:	Lansing	20	2	0	0	6	71	6	71	7
Minn:	Minneapolis	20	2	0	1	6	70	6	70	8
Miss:	Jackson	15	2	0	1	4	48	4	48	0
Mo:	Jefferson City	20	2	0	1	7	130	7	130	0
Mont:	Helena	14	2	0	1	0				
Nebr:	Lincoln	2	6	1	2	0				
Nev:	Las Vegas	17	4	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	3	0	1	9	36	9	36	1
N. Mex:	Santa Fe	14	3	0	1	0				
N.Y:	Albany	0				0				
	Buffalo	19	1	0	0	0				
	New York City	0				0				
N.C:	Gastonia	19	10	1	4	5	68	(b)		
N. Dak:	Bismarck	19	4	1	2	3	12	3	12	0
Ohio:	Cincinnati	0				0				
	Columbus	2	1	0	1	0				
	Painesville	20	1	0	0	9	149	9	149	28
Okla:	Oklahoma City	10	6	1	2	1	28			
	Ponca City	11	3	1	1	3	43	3	43	0
Oreg:	Portland	20	1	0	0	5	56	5	56	3
Pa:	Harrisburg	16	4	0	1	0				
P.R:	San Juan	0				0				
R.I:	Providence	20	2	0	0	0				
S.C:	Columbia	19	4	0	1	4	128	4	128	0
S. Dak:	Pierre	19	8	1	3	0				
Tenn:	Nashville	19	3	0	1	6	109	6	109	0
Tex:	Austin	20	5	1	3	3	45	(b)		
	El Paso	18	4	0	1	0				
Utah:	Salt Lake City	30	2	0	1	5	21	5	21	5
Vt:	Barre	19	5	0	2	5	32	5	32	2
Va:	Richmond	17	1	0	0	0				
Wash:	Seattle	8	0	0	0	4	74	(b)		
	Spokane	14	2	0	1	0				
W. Va:	Charleston	20	3	0	1	6	41	6	41	6
Wisc:	Madison	19	1	0	0	9	110	9	110	7
Wyo:	Cheyenne	18	5	1	2	0				
Network summary		1,000	10	0	1	159	79	5	67	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

38

2. Canadian Air and Precipitation Monitoring Program,[1] September 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for September 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	4	0.0	0.0	0.0	28	1.6
Coral Harbour	4	.0	.0	.0	11	.3
Edmonton	4	.0	.0	.0	43	1.3
Ft. Churchill	4	.0	.0	.0	21	1.2
Fredericton	4	.0	.0	.0	10	1.0
Goose Bay	4	.0	.0	.0	15	1.2
Halifax	7	.1	.0	.1	17	1.1
Inuvik	4	.0	.0	.0	22	.9
Montreal	4	.0	.0	.0	15	1.0
Moosonee	4	.1	.0	.0	29	1.7
Ottawa	4	.1	.0	.0	18	1.3
Quebec	4	.0	.0	.0	17	1.3
Regina	4	.0	.0	.0	20	.3
Resolute	4	.0	.0	.0	14	1.1
St. John's, Nfld	4	.0	.0	.0	13	1.3
Saskatoon	4	.0	.0	.0	53	.6
Sault Ste. Marie	4	.1	.0	.0	20	1.7
Thunder Bay	4	.1	.0	.0	15	1.0
Toronto	4	.0	.0	.0	10	1.0
Vancouver	4	.0	.0	.0	19	1.5
Whitehorse	4	.0	.0	.0	18	.7
Windsor	1	.0	.0	.0	13	1.4
Winnipeg	4	.1	.0	.0	35	2.1
Yellowknife	4	.0	.0	.0	30	1.1
Network summary	96	0.1	0.0	0.0	18	1.2

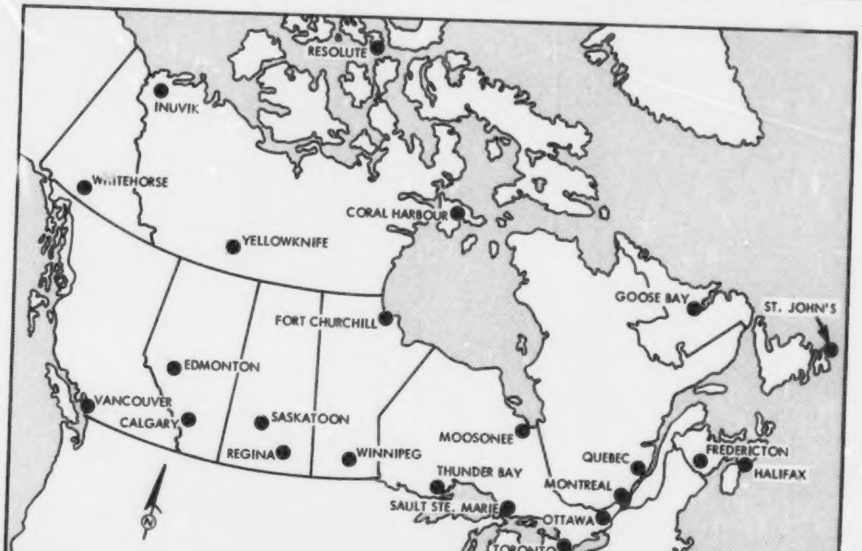
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

39

3. Pan American Air Sampling Program
September 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The September 1972 air monitoring results from the participating countries are given in table 3.

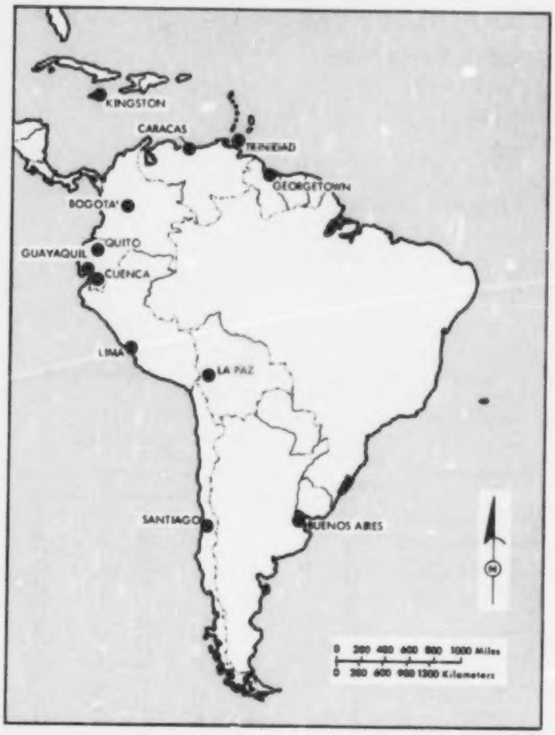

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, September 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	12	0.04	0.01	0.02
Chile:	Santiago	30	.12	.01	.05
Colombia:	Bogota	20	.01	.00	.01
Ecuador:	Cuenca	2	.00	.00	.00
	Guayaquil	19	.07	.00	.03
	Quito	19	.02	.00	.00
Guyana:	Georgetown	10	.01	.00	.01
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	7	.01	.00	.00
West Indies:	Trinidad	0			
Pan American summary		120	0.12	0.00	0.02

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program
September 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47

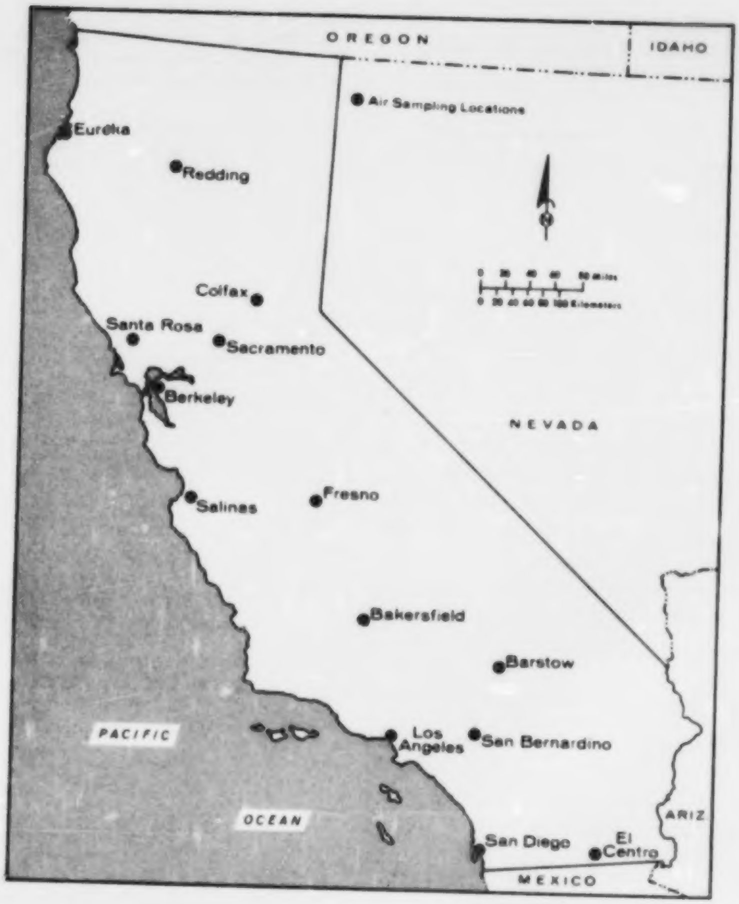
OREGON
IDAHO
Air Sampling Locations
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
Los Angeles
San Bernardino
PACIFIC
OCEAN
ARIZ
San Diego
El Centro
MEXICO
0 20 40 60 80 miles
0 20 40 60 80 100 kilometers

Figure 4. California air sampling program stations

millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for September 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air September 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	29	1.29	0.04	0.22
Barstow	30	.70	.06	.20
Berkeley	25	.20	.02	.09
Colfax	30	.29	.01	.12
El Centro	29	1.02	.05	.22
Eureka	29	.17	.00	.07
Fresno	29	.94	.06	.23
Los Angeles	29	.24	.00	.09
Redding	29	.21	.04	.12
Sacramento	29	.62	.04	.15
Salinas	29	1.88	.07	.32
San Bernardino	29	.79	.04	.18
San Diego	28	.49	.01	.11
Santa Rosa	30	.39	.01	.12
Summary	404	1.88	0.00	0.16

5. Mexican Air Moritoring Program May-August 1972

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comite de Seguridad Radiologíca (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general,

Table 5. Mexican gross beta radioactivity of airborne particulates, May–August 1972

Station	Gross beta radioactivity (pCi/m^3)			
	May	June	July	August
Chihuahua:				
Maximum	1.3	<0.2	<0.2	0.11
Minimum	.2	<.2	<.2	<.10
Average[a]	.3	<.2	<.2	<.10
Ensenada:				
Maximum	.6	<.2	<.2	.13
Minimum	<.2	<.2	<.2	.11
Average	<.2	<.2	<.2	([a])
Mérida:				
Maximum	.9	<.2	<.2	.15
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10
México, D.F:				
Maximum	<.2	<.2	<.2	<.10
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	([a])
Torreón:				
Maximum	1.1	<.2	<.2	.12
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10
Veracruz:				
Maximum	.6	<.2	<.2	.21
Minimum	<.2	<.2	<.2	<.10
Average	<.2	<.2	<.2	<.10

[a] Average not calculated for less than five samples.

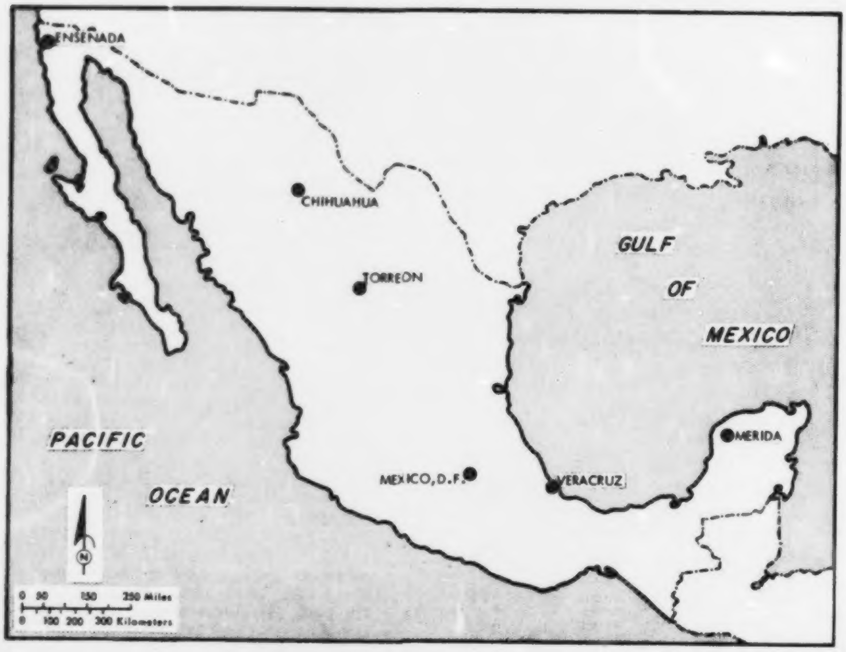

Figure 5. Mexican air sampling locations

including radiation in mines, uranium milling plant and the Nuclear Center of Mexico.

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F.; Chihuahua; Ensenada; Torreón; Veracruz; and Mérida (figure 5). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum and average beta radioactivity in surface air from May through August 1972 are presented in table 5. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

---

6. Plutonium in Airborne Particulates April-June 1972

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency (EPA), routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (*8*).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Laboratory, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from April-June 1972 are presented in table 6. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 6. Plutonium in airborne particulates April–June 1972

Location		Plutonium-238 (aCi/m^3)	Plutonium-239 (aCi/m^3)	Plutonium-^{239}Pu/^{238}Pu
Alaska:	Anchorage	10 ±2	47 ±8	5 ±1
Ariz:	Phoenix	6 ±2	62 ±9	10 ±3
Colo:	Denver	13 ±2	64 ±6	5 ±1
Hawaii:	Honolulu	7 ±1	39 ±4	6 ±1
La:	New Orleans	10 ±1	38 ±4	4 ±1
Md:	Baltimore	8 ±1	41 ±4	5 ±1
N.Y:	Buffalo	7 ±1	37 ±4	5 ±1
N.C:	Gastonia	18 ±2	66 ±6	4 ±1
S. Dak:	Pierre	7 ±1	45 ±4	7 ±1
Tex:	Austin	5 ±1	49 ±4	11 ±2
Wash:	Seattle	8 ±1	27 ±3	3 ±1

Other coverage in *Radiation Data and Reports:*

Period	Issue
April-June 1971	March 1972
July-September 1971	April 1972
October-December 1971	July 1972
January-March 1972	December 1972

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December (1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525-528 (October 1971).

(*7*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

(*8*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552-553 (October 1970).

Air Surveillance Network, September 1972

National Environmental Research Center-Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center-Las Vegas (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

The stations are operated by State health de-

---

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

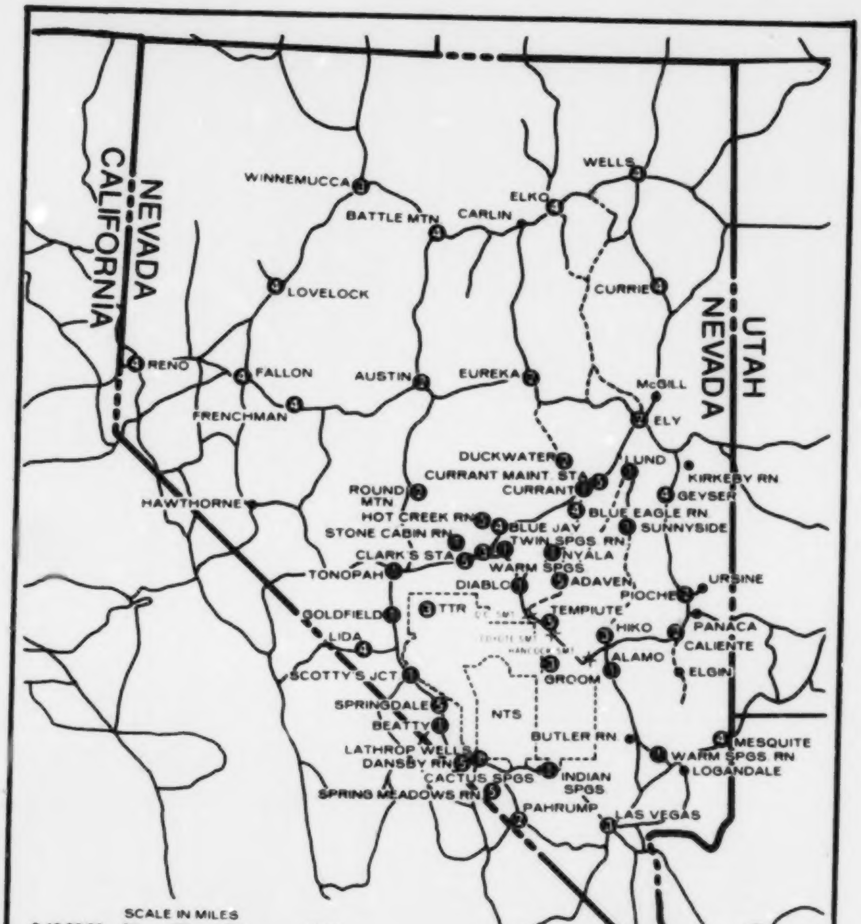
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
WELLS
ELKO
BATTLE MTN
CARLIN
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
LUND
CURRANT MAINT. STA
KIRKEBY RN
ROUND MTN
CURRANT
GEYSER
HAWTHORNE
HOT CREEK RN
BLUE EAGLE RN
STONE CABIN RN
BLUE JAY
SUNNYSIDE
CLARK'S STA
TWIN SPGS RN
NYALA
TONOPAH
WARM SPGS
DIABLO
ADAVEN
URSINE
PIOCHE
GOLDFIELD
TTR
TEMPIUTE
LIDA
HIKO
PANACA
CALIENTE
ALAMO
SCOTTY'S JCT
GROOM
ELGIN
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS. RN
DANSBY RN
LOGANDALE
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV air surveillance network stations in Nevada

44

Table 1. Summary of gross beta radioactivity concentrations in air September 1972

Locations		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average
Ariz:	Kingman	30	<0.2	<0.1	0.1
	Phoenix	28	<.2	<.1	.1
	Seligman	30	<.2	<.1	.1
	Winslow	30	<.2	<.1	.1
Ark:	Little Rock	19	<.2	<.1	.1
Calif:	Baker	30	<.2	<.1	.1
	Barstow	30	<.2	<.1	.1
	Bishop	30	.2	<.1	.1
	Death Valley Junction	30	.2	<.1	.1
	Furnace Creek	28	<.2	<.1	.1
	Indio	30	<.2	<.1	.1
	Long Pine	30	.2	<.1	.1
	Needles	25	<.2	<.1	.1
	Ridgecrest	30	.2	<.1	.1
	Shoshone	29	<.2	<.1	.1
Colo:	Denver	20	<.2	<.1	.1
	Durango	30	.2	<.1	.1
Idaho:	Boise	30	<.2	<.1	.1
	Idaho Falls	18	.2	<.1	.1
	Preston	30	.2	<.1	.1
	Twin Falls	30	<.2	<.1	.1
Iowa:	Iowa City	20	<.2	<.1	.1
	Sioux City	27	<.2	<.1	.1
Kans:	Dodge City	30	<.2	<.1	.1
La:	Lake Charles	19	<.2	<.1	.1
	Monroe	16	<.2	<.1	.1
	New Orleans	18	<.2	<.1	.1
Minn:	Minneapolis	20	<.2	<.1	.1
Miss:	Joplin	27	<.2	<.1	.1
	St. Joseph	30	<.2	<.1	.1
	St. Louis	30	<.2	<.1	.1
Nebr:	North Platte	26	<.2	<.1	.1
Nev:	Alamo	29	<.2	<.1	.1
	Austin	11	.3	<.1	.1
	Battle Mountain	30	.3	<.1	.1
	Beatty	30	<.2	<.1	.1
	Blue Eagle Ranch (Currant)	28	<.2	<.1	.1
	Blue Jay	30	<.2	<.1	.1
	Caliente	30	<.2	<.1	.1
	Currant Ranch	30	.2	<.1	.1
	Currie	29	.2	<.1	.1
	Diablo	30	<.2	<.1	.1
	Duckwater	24	.2	<.1	.1
	Elko	36	.2	<.1	.1
	Ely	28	<.2	<.1	.1
	Eureka	30	.2	<.1	.1
	Fallini's Twin Springs Ranch	30	<.2	<.1	.1
	Fallon	30	<.2	<.1	.1
	Frenchman Station	20	<.2	<.1	.1
	Geyser Maintenance Station	23	<.2	<.1	.1
	Goldfield	30	.3	<.1	.1
	Groom Lake	28	.2	<.1	.1
	Hiko	30	.2	<.1	.1
	Indian Springs	30	<.2	<.1	.1
	Las Vegas	21	<.2	<.1	.1
	Lathrop Wells	28	<.2	<.1	.1
	Lida	30	<.2	<.1	.1
	Lovelock	30	.2	<.1	.1
	Lund	29	<.2	<.1	.1
	Mesquite	30	<.2	<.1	.1
	Nyala	29	<.2	<.1	.1
	Pahrump	9	<.2	<.1	.1
	Pioche	30	<.2	<.1	.1
	Reno	30	<.2	<.1	.1
	Round Mountain	29	<.2	<.1	.1
	Scotty's Junction	30	.2	<.1	.1
	Stone Cabin Ranch	23	<1.4	<.1	.1
	Sunnyside	26	<.2	<.1	.1
	Tonopah	30	<.2	<.1	.1
	Tonopah test range	25	<.2	<.1	.1
	Warm Springs	26	.2	<.1	.1
	Warm Springs Ranch	30	<.2	<.1	.1
	Wells	31	<.2	<.1	.1
	Winnemucca	30	<.2	<.1	.1
N. Mex:	Albuquerque	20	.2	<.1	.1
	Carlsbad	29	<.2	<.1	.1
Okla:	Muskogee	30	<.2	<.1	.1
Oreg:	Burns	29	<.2	<.1	.1
	Medford	20	<.1	<.1	.1
S. Dak:	Aberdeen	30	<.2	<.1	.1
	Rapid City	30	.2	<.1	.1
Tex:	Abilene	28	.2	<.1	.1
	Amarillo	29	<.2	<.1	.1
	Austin	20	<.2	<.1	.1
	Fort Worth	30	<.3	<.1	.1

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, September 1972—continued

Locations		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Bryce Canyon	28	<.1	<.1	.1
	Cedar City	28	<.2	<.1	.1
	Delta	30	<.2	<.1	.1
	Dugway	30	.3	<.1	.1
	Enterprise	30	<.2	<.1	.1
	Garrison	30	<.2	<.1	.1
	Logan	29	.2	<.1	.1
	Milford	28	<.2	<.1	.1
	Monticello	26	.4	<.1	.1
	Parowan	27	<.2	<.1	.1
	Provo	30	.3	<.1	.1
	Roosevelt	30	.2	<.1	.1
	Salt Lake City	29	<.1	<.1	.1
	St. George	30	<.2	<.1	.1
	Wendover	30	<.2	<.1	.1
Wash:	Seattle	24	<.2	<.1	.1
	Spokane	15	<.2	<.1	.1
Wyo:	Rock Springs	30	.2	<.1	.1
	Worland	30	<.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reported value of 0.1 pCi/m³ is reported as <0.1.

partment personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A com-

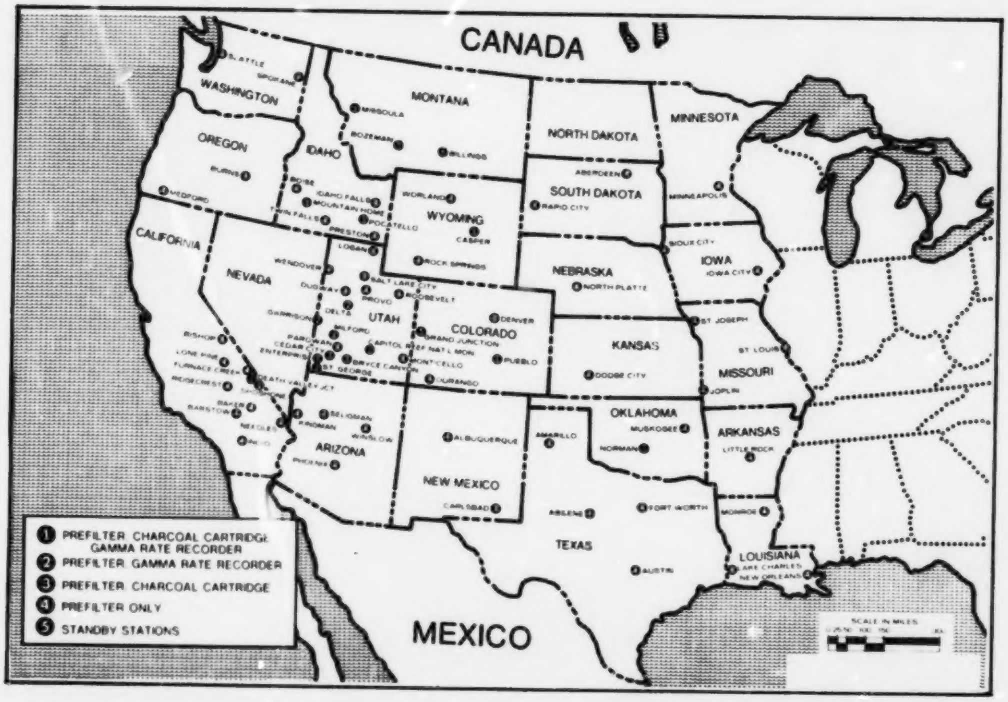
CANADA
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
LOGAN
WYOMING
WORLAND
CASPER
ROCK SPRINGS
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNEAPOLIS
SIOUX CITY
IOWA
IOWA CITY
CALIFORNIA
NEVADA
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
GARRISON
UTAH
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
CAPITOL REEF NAT'L MON
BRYCE CANYON
ST. GEORGE
MONTICELLO
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
KANSAS
DODGE CITY
ST. JOSEPH
ST. LOUIS
MISSOURI
JOPLIN
BISHOP
LONE PINE
FURNACE CREEK
DEATH VALLEY JCT
RIDGECREST
SHOSHONE
BAKER
BARSTOW
NEEDLES
INDIO
SELIGMAN
KINGMAN
WINSLOW
ARIZONA
PHOENIX
ALBUQUERQUE
NEW MEXICO
CARLSBAD
AMARILLO
OKLAHOMA
MUSKOGEE
NORMAN
ARKANSAS
LITTLE ROCK
ABILENE
FORT WORTH
TEXAS
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
SCALE IN MILES
① PREFILTER CHARCOAL CARTRIDGE GAMMA RATE RECORDER
② PREFILTER GAMMA RATE RECORDER
③ PREFILTER CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS

Figure 2. NERC-LV air surveillance stations outside Nevada

plete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta concentration in air for each of the network stations. The highest gross beta concentration within the network was less than 1.4 pCi/m^3 at Stone Cabin Ranch, Nev.; however, this was based upon a small sample volume of 39 m^3. The next highest concentration was 0.4 pCi/m^3, which was at Monticello, Utah. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m^3) are reported as <0.1 pCi/m^3. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during September 1972.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

47

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Strontium-90 in Human Bone, October-December 1971[1]

Office of Radiation Programs
Environmental Protection Agency

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age independent (1). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory, Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an

---

[1] Period during which death or surgical procedure occurred.

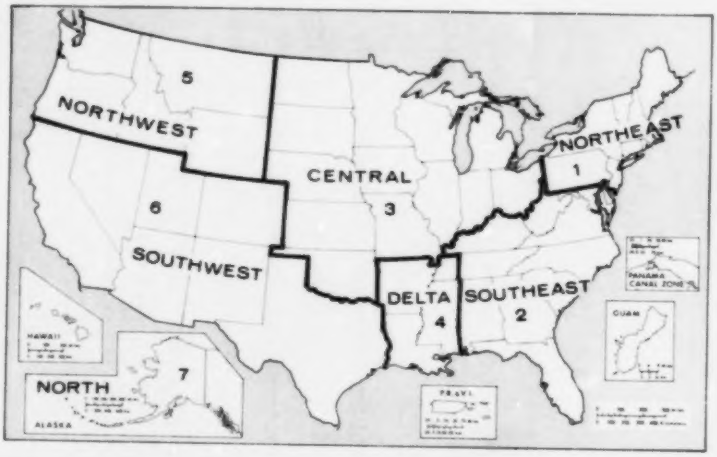

Figure 1. Geographical regions for human bone sampling

Table 1. Strontium-90 in human bone, October–December 1971

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
New York	V, R	0	F	41.5 ± 5.9	31.9	1.30
Massachusetts	V	1	M	78.9 ±11.2	32.8	2.41
New York	V	2	F	75.4 ± 8.5	29.3	2.57
	V	3	M	40.5 ± 9.8	34.7	1.17
	V	3	M	67.0 ± 8.0	40.0	1.67
Massachusetts	V	3	F	46.7 ± 6.9	25.5	1.83
New York	V	4	M	23.4 ± 5.5	18.1	1.29
	V	4	F	73.4 ± 8.9	36.9	1.99
	V	15	F	93.4 ± 9.5	51.1	1.83
New Jersey	V, R, S	16	F	116.9 ±12.6	64.4	1.81
New York	V	16	F	67.6 ± 9.0	49.5	1.37
	V	16	M	65.7 ±10.8	29.9	2.20
	V	17	M	67.4 ± 8.9	47.7	1.41
Pennsylvania	V	18	F	94.3 ± 9.1	50.3	1.87
	V, R, I	22	M	256.5 ±15.9	78.1	3.29
New York	V	22	M	54.9 ± 6.6	37.7	1.45
	V	24	M	72.6 ± 9.9	40.1	1.81
Massachusetts	V	24	M	50.0 ± 8.7	23.9	2.09
Southeast:						
North Carolina	V	3	M	109.9 ±12.6	29.0	3.78
	V	5	M	118.4 ±11.6	36.6	3.24
Florida	V	5	M	56.5 ± 6.7	31.3	1.80
North Carolina	V	6	F	108.2 ±11.4	36.8	2.94
Maryland	V	7	M	67.3 ±11.0	34.1	1.97
	V	9	M	55.2 ± 7.4	27.8	1.98
South Carolina	V	10	F	154.7 ±12.9	49.5	3.13
	V	11	M	80.4 ± 9.1	29.7	2.70
Maryland	V	13	M	70.8 ± 9.1	36.3	1.95
	V	14	M	61.0 ± 8.8	46.4	1.31
South Carolina	V	17	M	139.7 ±10.2	49.2	2.84
Maryland	V	18	M	103.8 ± 9.8	54.0	1.92
North Carolina	V	18	F	76.1 ±11.5	44.7	1.70
Maryland	V	19	M	59.6 ± 6.8	45.4	1.31
	V	19	M	90.5 ±10.8	53.4	1.69
	V	19	M	69.8 ± 9.1	54.0	1.29
	V	19	F	109.6 ±13.0	52.8	2.07
South Carolina	V	20	M	69.6 ± 8.8	53.0	1.31
Maryland	V	20	M	90.6 ± 8.9	49.3	1.84
	V	20	M	119.0 ± 9.9	44.8	2.65
	V	21	F	114.9 ±11.8	57.3	2.01
South Carolina	V	21	M	113.0 ± 9.5	46.4	2.44
D.C	V	21	M	63.2 ± 7.7	46.2	1.37
Maryland	V	21	M	108.3 ±12.5	63.1	1.72
	V	22	M	158.5 ±13.3	62.1	2.55
	V	22	M	71.6 ± 7.7	51.2	1.40
	V	23	M	55.5 ± 6.4	39.3	1.41
	V	23	M	82.9 ±10.9	57.5	1.44
	V	24	M	63.9 ± 9.9	53.5	1.19
	V	24	M	83.9 ± 9.3	50.6	1.66
	V	25	M	98.0 ±11.8	55.5	1.77
Central:						
Wisconsin	V	1	M	62.3 ± 7.3	28.6	2.18
	V	2	F	48.4 ± 7.6	28.2	1.72
	V	3	M	45.9 ± 6.1	32.0	1.43
Minnesota	V	6	M	63.9 ± 7.7	33.6	1.90
Wisconsin	V	7	M	54.2 ± 8.0	28.7	1.89
Michigan	V	9	M	36.7 ± 5.4	37.4	.98
Minnesota	V	13	F	70.6 ± 9.7	44.5	1.59
Wisconsin	V	14	M	89.7 ±10.8	60.8	1.47
Ohio	V	14	M	101.1 ±12.5	58.0	1.74
	V	15	M	90.5 ± 8.3	51.8	1.75
	V	16	M	131.3 ±11.8	55.6	2.36
	V	17	F	141.3 ±14.0	61.3	2.30
	V	17	M	123.0 ±11.0	59.1	2.08
	V	18	M	111.1 ±11.7	54.4	2.04
	V	18	M	78.6 ±11.0	52.1	1.51
	V	18	M	105.8 ±11.7	53.6	1.98
	V	18	M	78.1 ± 9.6	54.2	1.44
	V	19	M	66.2 ± 9.8	54.0	1.23
	V	19	F	115.0 ±12.5	51.5	2.23
	V	19	M	116.4 ±10.1	51.7	2.25
	V	19	F	88.4 ±10.1	54.6	1.62
Minnesota	V	20	M	56.5 ± 7.3	48.9	1.16
Ohio	V	20	M	88.6 ±12.8	65.5	1.35
	V	20	M	77.9 ± 7.8	42.8	1.82
Michigan	V	21	M	81.7 ± 9.4	57.7	1.42
Minnesota	V	21	M	48.4 ±11.0	61.2	.79
Michigan	V	21	M	167.1 ±16.0	64.0	2.61
	V	21	F	143.0 ±15.3	70.6	2.03
Ohio	V	21	M	67.2 ± 8.4	50.7	1.33
	V	22	M	62.3 ± 8.4	54.3	1.15
	V	22	M	86.0 ±10.1	59.3	1.45
Michigan	V	22	F	94.7 ±11.7	78.5	1.21
	V	23	M	65.6 ± 8.8	53.5	1.23
	V	23	M	93.6 ±10.6	56.6	1.65
	V	23	M	71.8 ± 7.9	57.5	1.25
	V	24	M	73.2 ±12.3	62.8	1.17
	V	24	M	70.1 ± 8.7	45.8	1.53
	V	25	M	59.8 ± 7.6	59.4	1.01

See footnotes at end of table.

Table 1. Strontium-90 in human bone, October–December 1971—continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northwest:						
Washington	V	4	F	77.9 ± 8.3	27.6	2.82
	V	6	M	56.0 ± 7.7	32.6	1.72
	F	7	M	168.8 ± 22.4	102.5	1.65
	V	10	M	65.7 ± 7.3	30.5	2.16
	A	10	F	140.5 ± 19.7	146.6	.96
Oregon	F	15	M	321.6 ± 31.5	185.4	1.73
	V	21	M	48.7 ± 8.0	22.2	2.19

[a] Type of bone, V, vertebrae; R, rib; S, sternum; I, ilium; F, femur; and A, arm.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the fourth quarter (October-December) of 1971 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–6*). This is the last report in which concentrations of strontium-90 and calcium will be reported for individual samples. Samples collected after 1971 will be composited by age and by geographical region and analyzed for plutonium-239, strontium-90, and calcium.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-March 1971	March 1972
April-June 1971	May 1972
July-September 1971	August 1972

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

(*6*) BARATTA, E. J., E. S. FERRI, and M. A. WALL. Strontium-90 in human bones in the United States, 1962–1966. Radiol Health Data Rep 11:183–186 (April 1970).

50

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Knolls Atomic Power Laboratory and Mound Laboratory.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2] January-December 1970

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the Naval Reactors Program of the AEC in the development of atomic power reactors for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the Kesselring site, located as shown in figure 1.

Knolls site

The Knolls site is located 5 miles east of Schenectady, N.Y., on the south bank of the Mohawk River. It consists of approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

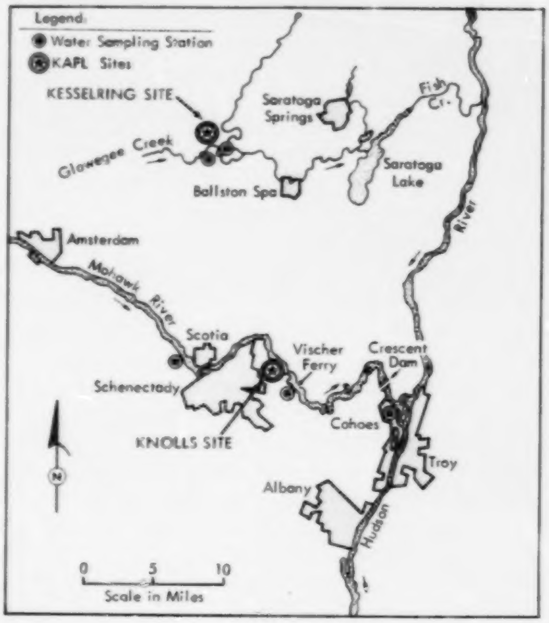

Figure 1. Environmental monitoring locations, KAPL

The Knolls site releases small amounts of radioactive materials both to the atmosphere and to the Mohawk River. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted both on- and offsite at the Knolls site for the following purposes: 1) to audit the operational control of radioactive waste released to the environment, and 2) to ascertain compliance with the radioactivity standards established by the AEC.

---

[2] Summarized from "Knolls Atomic Power Laboratory, Knolls Site and Kesselring Site, Annual Environmental Monitoring Report, January-December 1970."

Air monitoring

Potentially radioactive exhaust air from Knolls Site operations is filtered and monitored prior to discharge to the environment. Continuous samples of the effluent are collected and these samples are analyzed on a weekly basis for gross alpha and beta-gamma activity and for selected radionuclides. Monitoring results for 1970 indicate a total discharge of 2.185 mCi consisting of 0.236 mCi of alpha particulate activity, 0.62 mCi of beta-gamma particulate activity and 1.329 mCi of iodine-131. During 1970, the radioactivity concentration in the effluent from each stack averaged less than 5 percent of the appropriate environmental concentration guide for air as given in AEC Manual Chapter 0524.

Liquid waste monitoring

All sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The collected waste water is processed and sampled and the samples analyzed to verify that the radioactivity concentration and the total activity content of the processed waste are within established discharge limits. Subsequently, the processed waste water is discharged to the Mohawk River at a controlled rate. During discharge, samples are again collected and composite samples are analyzed.

A continuous proportional sample of the Knolls site combined sewer effluent is collected at the point of release to the Mohawk River. The radioactivity concentration in the effluent is continuously monitored and recorded by passing a portion of the sample through an in-line, lead shielded gamma scintillation detection system. An aliquot of the collected sample is analyzed whenever an increase in the gamma count rate above the normal range of background fluctuations is observed on the recorder.

A total of 28 millicuries of beta-gamma and 0.69 millicuries of alpha activity was discharged to the Mohawk River during 1970. The annual average concentration of beta-gamma activity in the liquid waste was 59 pCi/liter or 6.6 percent of its effective environmental concentration guide for water. The annual average concentration for the uranium isotopes, which comprised 94.6 percent of the total alpha activity, was 1.4 pCi/liter, which is less than 0.01 percent of their effective environmental concentration guide.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse, 3 miles upstream from the Knolls site, and at the Vischer Ferry powerhouse, 1.7 miles downstream. The weekly water samples are composited and analyzed for radioactivity on a monthly basis.

The average beta-gamma concentrations in Mohawk River water samples for each month of 1970 are shown in table 1. These concentrations were all significantly less than the most restrictive environmental concentration guide for strontium-90 given in AEC Manual Chapter 0524.

Sediment Monitoring

The Mohawk River sediment monitoring program at the Knolls site consists of the collection and analyses of Mohawk River sediment in each of three calendar quarters; ice coverage

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1970 [a]

Month	Beta and gamma radioactivity[b] (pCi/liter)	
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)
January	NS	8.0 ±4.4
February	<4.8	<4.8
March	<4.8	<4.8
April	5.6 ±4.7	6.9 ±4.7
May	5.4 ±4.7	<4.8
June	5.4 ±5.0	<4.8
July	<4.8	<4.8
August	5.1 ±4.7	6.1 ±4.7
September	<4.8	6.9 ±4.7
October	<4.8	<4.8
November	<4.8	<4.8
December	<4.8	7.1 ±4.9

[a] A t-test of these results indicates that, at the 95-percent confidence level, there is no statististical difference between the upriver and downriver concentrations for 1970.

[b] Cesium-137-equivalent.

NS, no sample.

prevents collection during the first calendar quarter. Samples are collected at 15 specific locations and all are analyzed for gamma, gross beta and alpha radioactivity. In addition, selected samples are analyzed for strontium-90.

The average radioactivity concentrations in the quarterly samples of Mohawk River sediment for 1970 are given in table 2. A comparison of these monitoring results with data for previous years indicates that the small quantity of radioactivity discharged in liquid waste during 1970 did not result in an increase in the average radioactivity concentration in river sediment. The variations in quarterly sediment concentrations are within the normally observed ranges for previous years and are attributable to the effects of radioactivity in the sediment from discharges prior to 1964. General concentrations rapidly diminished with increased distances from the sewer outfall.

Liquid effluent monitoring

The principal Knolls Site outfall to the Mohawk River is the one via which processed sanitary and radioactive liquid wastes are discharged. In addition to this outfall, there are eight smaller outfalls via which river water used for cooling, natural stream water and river water pump house drain lines discharge. Although these outfalls are not connected to potential sources of radioactivity, commencing with the third quarter of 1970, they are sampled and the samples analyzed on a quarterly basis. All analytical results for the third and fourth quarters of 1970, were less than the minimum detectable concentrations for gross alpha and beta-gamma activities, strontium-90, and cesium-137.

Perimeter surveys

Surveys are made routinely of the radiation levels at the perimeter of Knolls Site facilities. The surveys for 1970 showed normal background radiation levels for the geographic location. The results of the surveys extrapolated to an annual exposure indicate average radiation levels of less than 0.1 rem per year.

Kesselring site

The Kesselring site, located on approximately 4,000 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its principal facilities; include the S3G and D1G prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

Air released from power plant buildings (S3G Hull and D1G Sphere) and the Fuel Service Facility are continuously monitored for air particulate activity. In-stack radioactivity concentrations averaged less than the appropriate concentration guide given in the AEC Manual, Chapter 0524 for the entire 1970 calendar year. The total airborne particulate radioactivity discharged to the environment during the calendar year 1970 was less than 2.65 mCi.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the

Table 2. Radioactivity concentrations in Mohawk River sediment, KAPL, 1970 [a]

1970	Number of samples	Total radioactivity (pCi/g wet weight)				Strontium-90 (pCi/g wet weight)		Cesium-137 (pCi/g wet weight)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
January-March	[b]NS								
April-June	15	0.22	<0.07-0.52	20	15 -25	0.39	0.37-0.43	0.89	0.41- 1.7
July-September	15	.26	.11- .40	17	12 -22	.32	<.21- .52	1.0	<.40- 6.8
October-December	9	.24	.11- .80	14	6.2-31	.31	<.21- .71	2.0	<.40-13

[a] Minimum detectable concentration for a 600 g sample of 90-percent confidence level:
alpha—0.07 pCi/g; beta-gamma—2.9 pCi/g; strontium-90—0.21 pCi/g; cesium-137—0.40 pCi/g; Concentration for 600 g sample detectable at 90-percent confidence level with ±30 percent precision: alpha—0.38 pCi/g; beta-gamma—11 pCi/g; strontium-90—0.77 pCi/g; cesium-137—1.4 pCi/g. The variation in the detectable levels is the result of differences in the size of sediment aliquots analyzed; i.e., alpha analysis, 10 g; beta analysis, 1 g; strontium-90, 10 g; cesium-137, total sample. Each sediment sample represents a surface area of 230 cm^2 to a depth of 1 inch.

[b] Samples not collected due to ice on the Mohawk River.

Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 R/a.

Radioactive liquid waste disposal

The liquid waste from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. The radioactive waste discharged to the Glowegee Creek in terms of total radioactivity in liquid wastes was 3.16 millicuries for 1970. Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 1 percent of the respective AEC standards for this reporting period. The average result for unidentified radionuclides in the D1G and S3G effluents (8.3 and 79 pCi/liter) represent less than 1 percent and less than 3 percent, respectively of the applicable AEC standard (3 nCi/liter).

Water monitoring

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point. All Glowegee Creek water analysis results for beta and gamma radioactivity were below 50 pCi/liter, which is the measured concentration that may be considered valid at the 90 percent confidence level with a maximum error of 30 percent. These results indicate that the Kesselring Site effluent did not significantly influence the levels of radioactivity detected in the Glowegee Creek.

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 3.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation of the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, "Radiation Protection Standards."

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1969	October 1972

Table 3. Radioactivity in Glowegee Creek sediment, Kesselring Site, KAPL January–December 1970

1970	Location	Number of samples	Gross gamma radioactivity[a] (pCi/g dry weight)		Cobalt-60[a] (pCi/g dry weight) Average
			Average	Range	
January-March	Upstrean	NS			
	Downstream	2	10.4	9.6–11.2	1.3
April-June	Upstream	3	12.9	10.2–16.1	1.5
	Downstream	3	14.8	13.5–15.7	2.3
July-September	Upstream	3	6.1	7.5– 9.9	.99
	Downstream	3	13.9	10.5–17.7	1.9
October-December	Upstream	3	8.1	7.8– 8.5	1.2
	Downstream	3	11.9	9.5–15.5	1.6

[a] The minimum detectable activity (MDA) for cobalt-60 is 0.66 pCi/g of sediment while the MDA for the gross gamma radioactivity analysis is 0.18 pCi/g of sediment. These MDA's are based on average height and density values of sediment samples obtained using a 90-percent confidence level for the error.

NS, no sample, creek bottom frozen.

2. Mound Laboratory[3]
January-June 1970

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio. This location is 12 miles southwest of Dayton. The laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; separation, purification, and sale of stable isotopes of the noble gases; and development, design, and fabrication of radioisotopic heat sources for medical application and space exploration.

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha-particle emitters was used in the routine monitoring of environmental air within a radius of 20 miles from the laboratory during the collection period. Since the sampling zone is dependent on the wind direction it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected on Whatman No. 41 filter paper with a high volume air sampler. A 5-cm diameter circle, cut from the center of each filter paper, is processed and analyzed for polonium-210. The remainder of each filter paper is processed and analyzed for plutonium-238.

Airborne tritium oxide is monitored by bubbling air through 100-ml of a liquid scintillation counting solution with p-dioxane as the organic

Table 4. Atmospheric monitoring of polonium-210 Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (fCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	25	11	0.05
0–3 (downwind)	25	8	.04
3–5 (downwind)	25	12	.06
5–10 (downwind)	25	15	.07
10–15 (downwind)	25	14	.07
15–20 (downwind)	25	12	.06

[a] Lowest detectable level (LDL) for polonium-210 in air is 8 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which polonium-210 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at the location within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 33 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 5. Atmospheric monitoring of plutonium-238, Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (fCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	24	4.6	0.46
0–3 (downwind)	24	6.5	.65
3–5 (downwind)	24	5.7	.57
5–10 (downwind)	24	4.2	.42
10–15 (downwind)	24	4.0	.40
15–20 (downwind)	24	3.5	.35

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which plutonium-238 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at the location within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 33 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 1 pCi/m³.

Table 6. Atmospheric monitoring of tritium, Mound Laboratory environs, January–June 1970

Range (miles)	Number of samples	Average concentration[a] (pCi/m³)	Average as percent of AEC standards[b]
0–3 (upwind)	25	440	0.22
0–3 (downwind)	25	4,420	2.21
3–5 (downwind)	25	490	.24
5–10 (downwind)	25	340	.17
10–15 (downwind)	25	400	.20
15–20 (downwind)	25	320	.16

[a] Lowest detectable limit for tritium in air is 200 pCi/m³.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

---

[3] Summarized from "Environmental Monitoring Report, January-June 1970" (MLM-1784).

Table 7. Offsite water monitoring for radioactivity, Mound Laboratory environs, January-June 1970

Sampling location[a]	Number of samples	Polonium-210[b] (pCi/liter)		Plutonium-238[b] (pCi/liter)		Tritium[b] (hydrogen-3) (nCi/liter)	
		Average[c]	Percent of concentration limit	Average[c]	Percent of concentration limit	Average[c]	Percent of concentration limit
1	24	1.90	0.27	14.2	0.28	546.0	18.20
2	23	ND	ND	5.3	.11	14.0	.47
3	23	93.0	13.28	39.1	.78	336.0	11.20
4	23	4.70	.67	11.8	.24	15.0	.50
5	23	ND	ND	11.1	.22	15.0	.50
6	23	ND	ND	11.6	.23	12.0	.40
7	23	ND	ND	11.4	.23	12.0	.40
8	23	ND	ND	5.0	.10	14.0	.47
9	24	ND	ND	4.6	.09	16.0	.53

[a] See figure 2 for number of sampling locations. Sampling location and description: 1-Drainage ditch, 2-Upstream from laboratory, 3-Laboratory effluent, 4-250 yards downstream from location 3, 5-Chautauqua Road Bridge, 6-Chautauqua Dam, 7-Franklin, Ohio, 8-Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory; and 9-Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory.

[b] Lowest detectable level for polonium-210 in water is 1.80 pCi/liter. Lowest detectable level for plutonium-238 in water is 4.5 pCi/liter. Lowest detectable level for tritium in water is 6 nCi/liter.

[c] The applicable AEC radiation protection standards for uncontrolled areas are as follows:

Polonium-210 in water:	700 pCi/liter
Plutonium-238 in water:	5 nCi/liter
Tritium in water:	3 μCi/liter

ND, less than the lowest detectable limit.

solvent. A 20-ml aliquot of the resulting solution is counted directly in a liquid spectrometer for 10 minutes. The analysis is directed to tritium oxide rather than the gas because the AEC standard for the oxide is 200 times more restrictive than for the gas.

The results of the airborne monitoring program are presented in tables 4, 5, and 6. The average concentrations of polonium-210, plutonium-238 and tritium in the environment are below the AEC radiation protection standards.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3 being purified at the Mound Laboratory contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and discharged to the same drainage ditch as plu-

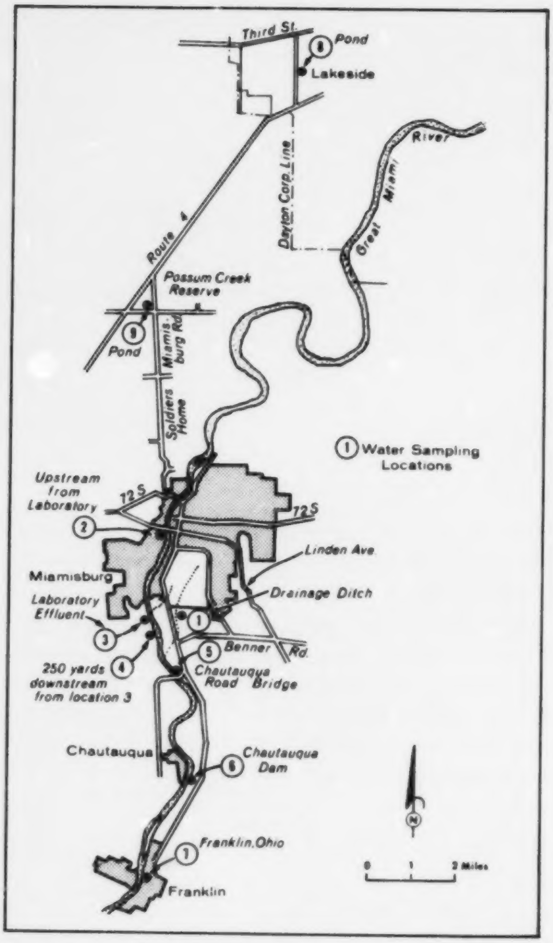
Third St.
⑧ Pond
Lakeside
Great Miami River
Dayton Corp. Line
Route 4
Possum Creek Reserve
⑨ Pond
Miamisburg Rd
Soldiers Home
① Water Sampling Locations
Upstream from Laboratory
②
72S
72S
Linden Ave
Miamisburg
Drainage Ditch
Laboratory Effluent
③
①
⑤ Benner Rd.
250 yards downstream from location 3
④
Chautauqua Road Bridge
Chautauqua
⑥ Chautauqua Dam
N
⑦ Franklin, Ohio
Franklin
0 1 2 Miles

Figure 2. Water sampling locations, Mound Laboratory

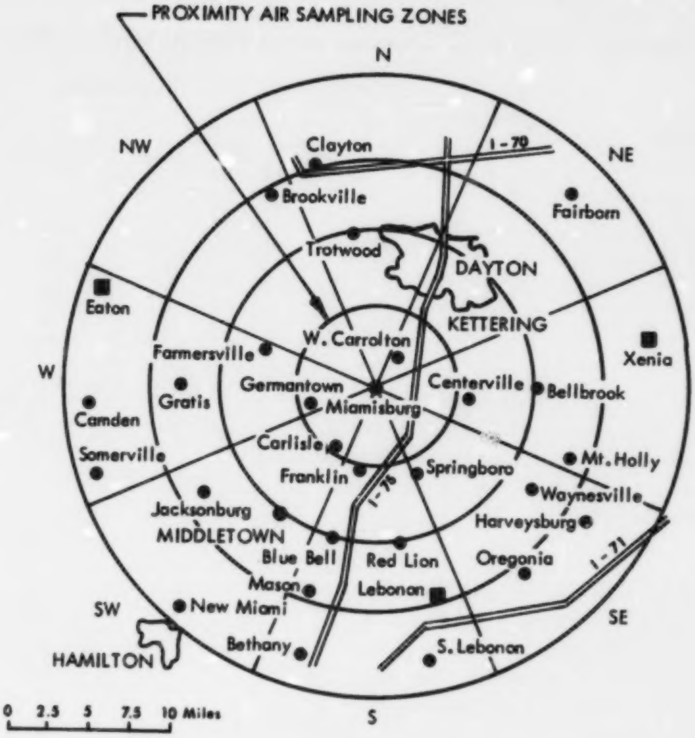
PROXIMITY AIR SAMPLING ZONES
N
NW
NE
W
E
SW
SE
S
Clayton
I-70
Brookville
Fairborn
Trotwood
DAYTON
KETTERING
Eaton
Xenia
W. Carrolton
Farmersville
Germantown
Miamisburg
Centerville
Bellbrook
Gratis
Camden
Somerville
Carlisle
Franklin
Springboro
Mt. Holly
Waynesville
Harveysburg
Jacksonburg
MIDDLETOWN
I-75
Blue Bell
Red Lion
Oregonia
I-71
Mason
Lebanon
New Miami
Bethany
S. Lebanon
HAMILTON
0 2.5 5 7.5 10 Miles

Figure 3. Offsite air sampling zones, Mound Laboratory

tonium waste. Some tritium-contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Two hundred milliliter water samples are collected weekly from the Great Miami River, the drainage ditch and two ponds northeast of Mound Laboratory (figure 2). All samples are analyzed for polonium-210, plutonium-238, and tritium. The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentrations of tritium, polonium-210, and plutonium-238 are given in table 7 for January-June 1970.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1969	December 1970

Reported Nuclear Detonations, December 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The U.S. Atomic Energy Commission announced that the United States recorded two sets of seismic signals, presumably from Soviet underground nuclear explosions. The signals originated at approximately 11:30 p.m. EST, December 9, 1972, and followed one another closely. Both sets of signals came from the Semipalatinsk nuclear test area. The first set was equivalent to those of an underground nuclear explosion in the yield range of 20–200 kilotons, and the second set was equivalent to the yield range of 200 kilotons—1 megaton.

The U.S. Atomic Energy Commission announced only one nuclear detonation for December 1972. An underground nuclear test with a yield range of 20 to 200 kilotons was conducted December 21, 1972 at the Nevada Test Site.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

58

☆U.S. GOVERNMENT PRINTING OFFICE: 1973 — 514-844/6

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TECHNOLOGY ASSESSMENT OF RISK REDUCTION EFFECTIVENESS OF WASTE TREATMENT SYSTEMS FOR LIGHT-WATER REACTORS. *J. E. Martin, F. L. Galpin,* and *T. W. Fowler. Radiation Data and Reports, Vol. 14,* January 1973, pp. 1–8.

The Environmental Protection Agency (EPA) routinely performs technology assessment of applications of nuclear energy that have the potential to introduce radioactive material into the environment. The Agency has extensively examined the performance of waste treatment systems for light water power reactors as a function of cost with regard to an examination of bases for environmental radiation standards and for EPA review of environmental impact statements for such plants. It was determined that significant and cost effective offsite dose reductions from gaseous discharges could be brought about by using available technology to holdup the gases until essentially krypton-85 remained; further dose reductions by cryogenic removal of krypton-85 did not appear to be justified in view of the costs involved. Similarly for liquid wastes, reasonable technology appears to stop just short of recycling waste streams to contain tritium.

KEYWORDS: Air, cost, light-water reactors, waste treatment, water.

ASSESSMENT OF THYROID INHALATION DOSES IN THE WESTERN UNITED STATES FROM THE CHINESE NUCLEAR TEST OF NOVEMBER 1971 *R. B. Evans, R. N. Snelling,* and *F. N. Buck. Radiation Data and Reports, Vol. 14,* January 1973, pp. 9–16.

Following a nuclear detonation by the People's Republic of China measurable increases of radioactivity were detected over the western United States by the Air Surveillance Network which is operated by the National Environmental Research Center-Las Vegas. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 0.2 mrem at Scotty's Junction, Nev.

KEYWORDS: Airborne radioactivity, China, doses, iodine-131, nuclear detonation, tellurium-132, thyroid, western United States.

59

RADIATION DATA AND REPORTS

Volume XIV, Number 2, February 1973

***Radiation Data and Reports*, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.**

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Environmental Protection Agency
Atomic Energy Commission

CONTENTS

Page

REPORTS

Calculations of Environmental Radiation Exposures and Population Doses due to Effluents from a Nuclear Fuel Reprocessing Plant 59
J. A. Martin, Jr.

Assessment of Doses in the Western United States from a People's Republic of China Nuclear Test of January 7, 1972 77
R.B. Evans, R. N. Snelling, and F. N. Buck

DATA

SECTION I. MILK AND FOOD 85

Milk Surveillance, October 1972 85

Milk Surveillance Programs, April-June 1972, *NERC-LV* 97

Food and Diet Surveillance 100

SECTION II. WATER 101

Radioactivity in Kansas Surface Waters, January-December 1971 102

60

CONTENTS—continued

Page

Tritium Surveillance System, July-September 1972 104

Water Surveillance Programs, April-June 1972, *NERC-LV* 108

SECTION III. AIR AND DEPOSITION 115

Radioactivity in Airborne Particulates and Precipitation 115

1. Radiation Alert Network, October 1972 116
2. Canadian Air and Precipitation Monitoring Program, October 1972 118
3. Pan American Air Sampling Program, October 1972, *PAHO and EPA* 119
4. California Air Sampling Program, October 1972 119

Air Surveillance Network, October 1972 122

SECTION IV. OTHER DATA 125

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 125

1. Brookhaven National Laboratory, July-December 1970 125

Reported Nuclear Detonations, January 1973 128

Synopses iii

Guide for Authors ...... Inside back cover

RADIATION DATA AND REPORTS

Published under the direction of

W. D. Rowe
Deputy Assistant Administrator
for Radiation Programs

BOARD OF EDITORIAL ADVISORS

Capt. Myron I. Varon, MC, USN
Department of Defense
Dr. Milton W. Lammering
Environmental Protection Agency
Lee O. Tiffin
Department of Agriculture
Dr. Randall S. Caswell
Department of Commerce
Robert E. Simpson
Department of Health, Education, and Welfare
Dr. Martin B. Biles
Atomic Energy Commission

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary H. Nesdore
Illustrator	Marylee C. Hill

Address correspondence to the Editor, *Radiation Data and Reports*, Office of Radiation Programs, Parklawn 18B-40, Washington, D.C. 20460.

For subscriptions to *Radiation Data and Reports*, please use the order form on last page of this issue.

U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Calculations of Environmental Radiation Exposures and Population Doses Due to Effluents from a Nuclear Fuel Reprocessing Plant

James A. Martin, Jr.[1]

Effluent and environmental data pertinent to the Nuclear Fuel Services nuclear fuel reprocessing plant in West Valley, N. Y., were analyzed to determine doses to sample populations. Individual doses to the maximally exposed population group were considered. Population doses (man-rems) from air, fish, deer, and water pathways were calculated. The most significant radionuclides contributing to doses were tritium, krypton-85, strontium-90, cesium-134 and cesium-137. It was concluded that the impact of this facility upon humans was well below applicable guides in 1971.

Within the nuclear fuel cycle, the fuel reprocessing plant offers a great potential for significant impact on the environment. At fuel reprocessing plants, partially spent uranium and plutonium are recovered as valuable natural and national assets from the fuel assemblies discharged by nuclear power plants. It is at this stage in the fuel cycle that the bulk of long-lived fission products built up in the nuclear fuel are released from the fuel cladding. Although only small fractions of most nuclides are released to the offsite environment, the inventory itself is so large that small fractional releases may lead to a measurable environmental impact.

This report analyzes the effluent and environmental data pertaining to the Nuclear Fuel Services Fuel Reprocessing Plant (NFS) in West Valley, N. Y., to obtain a measure of the impact of the plant effluents upon humans. The impact is assessed in terms of the dose delivered to humans subjected to the radiation released to the environment by the NFS plant. Doses to sample populations during 1971 were calculated. The calculational approach taken herein amplifies upon that used in an earlier review (*1*) in that local and worldwide population doses (man-rem) are considered as well as individual doses (rems).

Doses were calculated using effluent data reported by NFS in their quarterly operating reports and semiannual environmental reports (*2-4*) and were supplemented by information from a number of other sources. The significant exposure pathways considered include air, milk, water, fish and game. Both submersion and inhalation doses were considered. The ingestion pathway was analyzed by assuming reasonable consumption levels for a standard man. The doses delivered by the various radionuclides released from the plant were calculated using techniques recommended by the International Commission on Radiological Protection (ICRP). The resultant doses are compared to the guidance promulgated by the ICRP and the U.S. Atomic Energy Commission (AEC). To the extent possible in the calculations, care was taken to subtract natural background and fallout activities; thus, all doses reported herein are those reasonably attributable to the NFS plant alone.

In order, the following sections present a summary of the results of the analysis, a de-

---

[1] Surveillance Branch, Field Operations Division, Office of Radiation Programs, Environmental Protection Agency, Rockville, Md. 20852.

Mention of commercial products used in connection with work reported in this article does not constitute an endorsement by the Environmental Protection Agency.

62

scription of plant operations, individual doses via the air and water effluent exposure vectors, and population doses along these vectors. Recommendations based upon the analyses, references, and bibliography complete this report.

Summary of results

Individual doses were calculated for the average of the maximally exposed population groups in the immediate vicinity of the Nuclear Fuel Services facility. Ingestion population doses (man-rem) were calculated for the local maximally exposed population group, namely, sportsmen consuming fish and game having contact with the creek system carrying liquid plant effluents. Local (1 to 50-mile radius) and worldwide krypton-85 submersion population doses were also calculated. A summary of the NFS plant operations and doses to population groups for 1971 is presented in table 1. It is noted, however, that future plant capacity at NFS will increase by a factor of 15 over 1971 throughput. Also, most fuel reprocessed at NFS to date had been cooled for much longer than the 150 days minimum required by the NFS license. Further, NFS plans to add a fuel fabrication plant nearby. Thus, surveillance of the radiation effluents from these facilities should be maintained.

Table 1. Summary of significant data and calculations

NFS Plant operations—1971:	
Fuel reprocessed:	68.8 tonnes 794 gigawatt-days exposure 11,500 megawatt-days/tonne burnup
Major stack effluents:	2.21×10^5 Ci krypton-85 1,070 Ci tritium
Major water effluents:	4×10^3 Ci tritium 6.6 Ci strontium-90 0.21 Ci iodine-129 77 Ci gross beta, other than tritium 0.06 Ci gross alpha
Individual doses (first year):	
Average whole body doses for an individual in the maximally exposed group:	
Tritium transpiration and inhalation	0.02 mrem
Krypton-85 air submersion	.01
Deer meat ingestion	.5
Fish meat ingestion	2.5
Creek bank occupancy	2.8
Total	5.83 mrem
ICRP recommended limit	170 mrem
Whole body population doses (first year):	
Tritium in drinking water [a]	16 man-rem
Krypton-85 submersion (0–50 miles)	1
Deer meat ingestion	5
Fish meat ingestion	1
Total	23 man-rem
Krypton-85 submersion (worldwide)	6 man-rem (first year) 100 man-rem (total dose commitment)

[a] Includes estimated populations served by municipal intakes in Lake Erie, Lake Ontario and along the St. Lawrence River to Cornwall, Ontario, Canada.

NFS plant operations

Nuclear Fuel Services began reprocessing spent nuclear fuel in April 1966 under AEC License No. CSF-1 (AEC Docket No. 50-201) and operated continually throughout 1971. The basic purpose of the plant is to recover uranium and plutonium from spent fuel elements from nuclear power plants. The terms of the NFS license essentially allow a maximum of 1 tonne of fuel per day to be processed; the plant capacity is about 300 tonnes per year. About 30 percent of a power plant's fuel inventory, or about 30 tonnes of fuel from a 1000-megawatt (electric) plant, is removed annually for reprocessing. The composition of spent fuel varies with exposure, burnup, reactor design, operating characteristics, fuel location in the core and fuel cooling time, but typical values of some significant parameters are given in table 2 (*5*).

All fuel is cooled at least 150 days before processing. Upon receipt at NFS, fuel containers are unloaded under water and the fuel is transferred to a 28-foot deep storage pool. Within this pool, the elements can be visually inspected, and the pool water is surveyed to detect radioactivity which may leak from damaged fuel elements.

b3

Table 2. Significant radionuclide inventories of typical[a] light water reactor fuels at 33,000 MWd/tonne uranium, 30 MW/tonne uranium, 180 days cooling[b]

Fuel composition:

Uranium—averaging 0.85 weight percent uranium-235
Plutonium—9 to 12 kg Pu/tonne uranium

Radionuclide inventory:

Gross beta and gamma fission products—4.2×10^6 Ci/tonne uranium.

Strontium-89	65,000	Ci/tonne uranium
Strontium-90	76,600	Ci/tonne uranium
Krypton-85	11,000	Ci/tonne uranium
Tritium	690	Ci/tonne uranium
Iodine-131	0.165	Ci/tonne uranium
Iodine-129	0.037	Ci/tonne uranium
Ruthenium-rhodium-106	388,000	Ci/tonne uranium
Cesium-134	209,000	Ci/tonne uranium
Cesium-137	107,000	Ci/tonne uranium
Cobalt-60	6,050	Ci/tonne uranium
Ruthenium-103	52,200	Ci/tonne uranium

[a] Actual composition varies with burnup, reactor design, core placement, operating characteristics and cooling time.

[b] Personal communication, Nuclear Fuel Services, Inc. Data calculated using ORIGEN code.

When required for reprocessing, the fuel assemblies are moved into a hot cell where the end-fitting hardware is removed and the fuel elements (rods) are mechanically sheared into small pieces. It is at this point that the volatile fission products begin to be released to the off-gas treatment systems and thence to the environment. The pieces are collected in metal baskets and loaded into large vats called dissolvers.

Dissolution of the fuel begins when nitric acid is injected into the loaded dissolvers. One metric ton of uranium (tonne U) is dissolved to liquid form in about 4 hours. Gases trapped in the fuel, such as krypton-85, are released during the dissolution. The exhaust from the dissolvers eventually passes through two HEPA filters in tandem (99.97 percent rated removal efficiency each for particles greater than 0.3 μm) before being released from the 60-meter stack.

High-level liquids (ca. 400 gallons/tonne U) are stored in underground vaults onsite in tanks with filter vents connected to the stack. Low-level liquids are released to the offsite environment after treatment, storage and delay in three large lagoons (5 million gallons total capacity). The rate of discharge from the lagoons is controlled so as to maintain a gross beta concentration in the local offsite creek (Cattaraugus Creek) below 150 pCi/liter. The insoluble metal cladding materials are monitored to establish completeness of dissolution of fuel and are buried in an AEC-licensed onsite solid waste storage area. New York State licenses a low-level waste burial site at the facility.

The dissolver solution undergoes solvent extraction which separates the fission products from the contained uranium and plutonium, and also separates uranium and plutonium from each other. Purification (from trace fission products) occurs before the final products, uranyl nitrate and plutonium nitrate, are recovered and stored in licensed shipping containers.

References *4-6* contain more detailed information regarding the plant fuel reprocessing cycle.

In May 1971, NFS began operating a one million dollar, low-level, liquid effluent cleanup plant to reduce the concentrations of strontium and cesium radionuclides in the low-level liquid waste effluent to below MPC_w at the point of release from the lagoons. As of spring 1972, the plant was operating under an interim AEC technical specification on liquid effluents. The AEC has set an eventual goal that all radionuclides in liquid effluents, including tritium, are to be below MPC_w at the plant holdup lagoon outfall before dilution in the onsite Buttermilk Creek (*7*). The precipitation and ion exchange plant reduced cesium radionuclides to below this specification, but not strontium (*3*); these, plus ruthenium, were found to be the most significant radionuclides in the low-level liquid waste effluent.

NFS ceased reprocessing in December 1971 and cleanup and decontamination procedures began in preparation for modifications to increase capacity (throughput). When again online, the plant licensed capacity will essentially triple to 3 tonne uranium/day.

In addition to the fuel reprocessing plant, NFS plans to build a fuel fabrication facility (*7,8*) on the 3,345-acre Western New York Nuclear Service Center (WNYNSC) owned by the New York Atomic and Space Development Authority. The fuel reprocessing site occupies

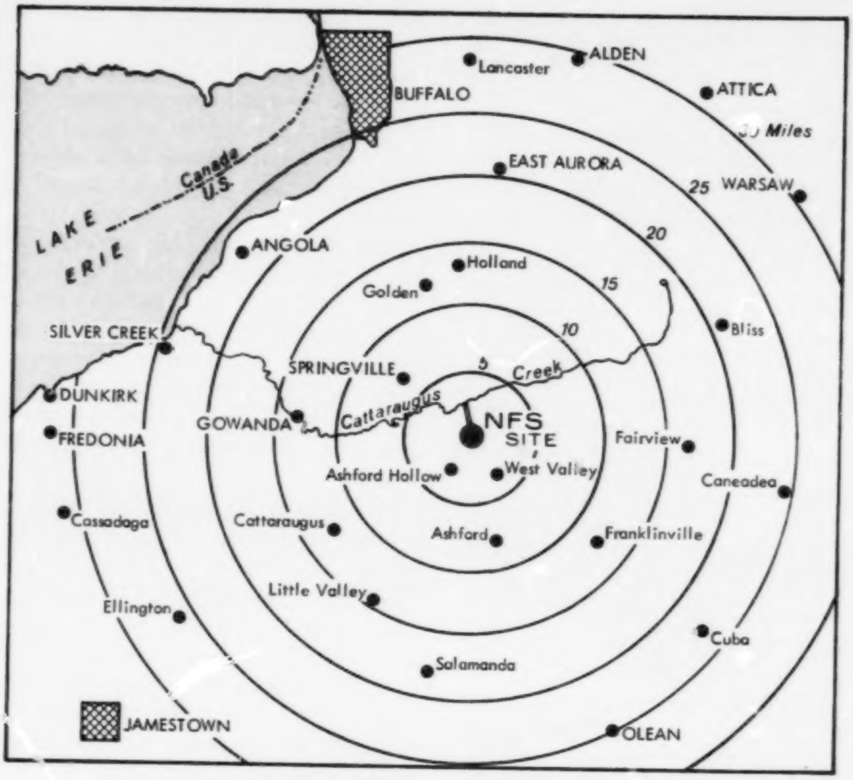
Lancaster
ALDEN
ATTICA
30 Miles
BUFFALO
EAST AURORA
25
WARSAW
Canada
U.S.
LAKE
ERIE
20
ANGOLA
Holland
15
Golden
Bliss
SILVER CREEK
10
SPRINGVILLE
5
Creek
DUNKIRK
Cattaraugus
NFS
SITE
GOWANDA
FREDONIA
Fairview
Ashford Hollow
West Valley
Caneadea
Cassadaga
Cattaraugus
Ashford
Franklinville
Little Valley
Ellington
Cuba
Salamanda
JAMESTOWN
OLEAN

Figure 1. Location of the Western New York Nuclear Service Center including the Nuclear Fuels Services site

180 acres of the WNYNSC (figure 1). The WNYNSC is shaped like a long-necked vase, the neck bounding Buttermilk Creek to its confluence with Cattaraugus Creek. Cattaraugus Creek flows 36 creek miles to Lake Erie. The creeks offer an average dilution factor of 1 to 2 x 10^3 to the lagoon outfall. These creeks and the stack are the primary vectors routing radionuclides to the offsite environment.

Dose from airborne activity

Source terms

Airborne radioactivity associated with the NFS facility arises principally at the cutting and dissolution stage. Tritium, krypton-85, and iodine-129 were potentially the most radiologically significant radioisotopes released from the stack during 1971. There are no facilities at NFS for collecting and storing krypton-85. The krypton-85 effluent data reported by NFS (table 3) (*2,3*) correlate very well with the assumption that 100 percent of the fuel's krypton-85 inventory is released from the stack.

Establishing credible source terms for tritium and iodine-129 is more complicated, the most serious uncertainty being that for iodine-129. Although a silver nitrate reactor was installed at NFS for iodine removal before stack release, it has not generally been used because of the long cooling time and the consequent decay of iodine-131 to insignificant levels. A mercurous-mercuric nitrate scrubber has generally been used. Some measurements indicate that at least 5 percent and possibly as much as 20 percent (*9,10*) of the radioiodine inventory is released from the stack.

Table 3. Source terms for NFS 1971 stack releases
(Curies released)

1971 quarter	^{85}Kr [a]	^{3}H [b]	^{129}I [c]	^{89}Sr	^{90}Sr	^{106}Ru	^{134}Cs	^{137}Cs
January-March	56,000	0.24	10×10^{-4}	0.2×10^{-4}	1×10^{-4}	6×10^{-4}	1×10^{-4}	4×10^{-4}
April-June	56,000	35	15×10^{-4}	2.4×10^{-4}	1.6×10^{-4}	3×10^{-4}	4×10^{-4}	2×10^{-4}
July-September	86,500	109	0.2×10^{-4}	—	0.3×10^{-4}	1×10^{-4}	0.2×10^{-4}	1×10^{-4}
October-December	22,300	930	1×10^{-4}	0.1×10^{-4}	0.5×10^{-4}	3×10^{-4}	0.7×10^{-4}	2×10^{-4}
1971 totals (Ci)	220,800	1,070	2.6×10^{-3}	2.7×10^{-4}	3.4×10^{-4}	13×10^{-4}	6×10^{-4}	9×10^{-4}

[a] From NFS 1971 environmental reports.
[b] 1.33 times for tritiated stack vapor reported in NFS 1971 environmental reports. See text for explanation of factor.
[c] From NFS 1971 environmental reports, ignoring possible gaseous releases not detected.

Semiannual NFS environmental reports for 1971 (*2,3*) contain iodine-129 data obtained from stack samplers, and such data are used herein. However, the possibility of much greater iodine-129 releases cannot be ignored. A complication to obtaining a credible source release term for iodine is the indication that gaseous organic iodides are formed in uncertain quantities during the dissolution process (e.g. methyl iodide and hypoiodous acid) (*10*). The NFS stack monitor data (table 3) accounted for only 0.3 percent of the iodine-129 inventory in the fuel processed at NFS in 1971 (the inventory being calculated using the data in tables 1 and 2). Yet very recently, low but detectable levels of iodine-129 have been found in local milk obtained from cows on winter feed (*11,21*); the concentrations fell sharply after the cows were placed on pasture feed in the spring of 1972. In 1971, the iodine-129 in the liquid effluent amounted to about 20 percent of the iodine-129 inventory in the fuel processed during that year. Some of this effluent was undoubtedly associated with earlier reprocessing.

Tritium stack release source terms are also somewhat in doubt, but to a lesser extent than for iodine-129. The NFS environmental reports for 1971 contain measured aqueous tritium activity releases obtained from Drierite water vapor traps installed in mid-1970 in the stack monitors. A series of measurements made at NFS by the Environmental Protection Agency (*13,14*) indicate that the total tritium released is 1.33 times the tritiated water vapor released. Thus, it was assumed that the total tritium released was 1.33 times the tritiated water vapor release measured and reported by NFS. This total amounted to 6 percent of the tritium inventory calculated using the data in tables 1 and 2 (some tritium is lost at the reactor, however).

Other radionuclides released from the stack, as reported by NFS (*2,3*) are listed in table 3. The quantities released were far less than for krypton-85 and tritium. Other radionuclides released in even less significant quantities are listed in reference 9.

Submersion and inhalation doses

Submersion and inhalation doses were calculated using ICRP (*15*) and FRC (*16*) methodology and exposure data reported by NFS. The krypton-85 exposures listed in table 4 for 16 compass directions were calculated by NFS using measured release rates and the long term sector averaged exposure equation (*17*):

$$\Psi = \left(\frac{2}{\pi}\right)^{1/2} \frac{f\,\Delta Q'\Delta t \exp - h^2/2\sigma_z^2}{\bar{u}\sigma_z\; 2\pi r/n} \qquad \ldots (1)$$

where: f = fractional wind frequency in a sector,
r = distance from the stack in meters,
h = effective stack height in meters,
n = number of sectors,
$2\pi r/n$ = sector width at distance r in meters,
σ_z = standard deviation of the vertical distribution of an assumed gaussian cloud, in meters,
$\bar{u}$ = average wind speed in the sector in m/s,
$\Delta Q'$ = average curies of activity released per second during time interval,

66

Δt = time interval of radioactive release in s, and

Ψ = ground level exposure of radioactivity in Ci-s/m³.

The exponential term in equation 1 rapidly approaches unity offsite and Ψ varies inversely with the product $r\sigma_z$ thereafter. σ_z is a monotonically increasing function of distance, values for which are also functions of stability class; higher values generally prevail for unstable wind conditions. n normally equals 16. An extensive discussion of these and other meteorological parameters is presented in references *17* and *18*.

The NFS meteorological data were obtained using instruments located onsite, principally at the top of the stack. Although NFS provides a yearly average joint frequency distribution (wind frequency, stability class and wind speed in 16 compass directions), the krypton-85 exposure data in table 4 were used in this analysis. These data were deemed most applicable since stack releases occurred over only a small fraction of the year and a wind rose corresponding only to the release periods should be used to calculate doses.

Expressed in exposure units, the ICRP recommended maximum permissible concentration in air (MPC_a) of krypton-85 for continuous occupancy by a nonoccupational individual is 3×10^{-7} Ci/m³ $\times$ 3.16×10^{7} s = 9.5 Ci-s/m³. The ICRP yearly whole (total) body submersion dose corresponding to this exposure is 500 mrem/year (assuming continuous, uniform exposure and a semi-infinite air cloud). Using these assumptions, the maximum whole body dose at 3 km due to krypton-85 submersion occurred in the west sector (table 4) and was 2.5 millirem for the year. The skin dose at this point from tritium submersion amounted to 1.1 microrem for the year. For the remaining radionuclides listed in table 3, submersion whole body doses were less than 10 percent of the tritium dose.

A complete yearly average joint frequency distribution corresponding to the exposure data in table 4 was not available for this study. Table 5 presents the meteorological summary that was available (*19*). The data in this table indicate that winds blowing to the west were predominantly of class B stability. With class B stability, the maximum site boundary dose would be higher than the 3 km dose by a factor of about seven. However, considering the pristine state of the immediate offsite environs of the NFS facility, the occupancy factor for the boundary locations most likely would be considerably less than 1/7, leading to a lower yearly dose than the 3 km west sector dose. Conversely, a small community does exist 3 km to the west, and assuming continuous occupancy for some of these individuals is reasonable.

Table 4. Krypton-85 exposure at 3,000 meters from plant stack, 1971[a]

Sector	1971 total (Ci-s/m³)
North	0.0104
North northwest	.0213
Northwest	.0026
West northwest	.0176
West	.0482
West southwest	.0105
Southwest	.0146
South southwest	.0305
South	.0358
South southeast	.0000
Southeast	.0420
East southeast	.0120
East	.0123
East northeast	.0007
Northeast	.0003
North northeast	.0056

[a] From NFS Environmental Report No. 11 (*3*).

Table 5. NFS 1971 annual average meteorological data

Fraction of occurance	Pasquill stability class [a]	Average wind speed at top of stack (m/s)
0.74	B	4.28
.20	D	3.49
.06	E	2.23

[a] 1. Stability based upon average wind variance.
2. Cross valley winds generally quite turbulent, Class B tending toward Class A.
3. Axial valley winds tend toward D.
4. Pasquill stability classes are described in references *17* and *18*.

Krypton-85 whole body dose

A discussion of the term "whole body dose" as used above is warranted. The ICRP "whole body dose" is predominantly a surface (skin) dose for primarily beta emitters such as krypton-85. The whole body (gonad) dose of the "maximum" krypton-85 exposed group described above was far less than the skin dose. The following analysis was used to bound the gonad dose. An estimate of the krypton-85-induced gonad dose was obtained using the semi-infinite cloud dose model (*20*). For the gamma component:

$$\dot{D} = 0.25\,\bar{E}_{\gamma}\chi(\text{rad/s}) \qquad \ldots (2)$$

where $\bar{E}_{\gamma}$ is the average gamma energy per disintegration in MeV and χ is the air concentration in Ci/m^3. Taking $\bar{E}_{\gamma}$ as the product of the krypton-85 gamma energy ($\bar{E}_{\gamma} = 0.513$ MeV) and gamma branching ratio (0.00413), the annual whole body gamma dose from krypton-85 is 5 mrem/year for continuous exposure to a semi-infinite gas cloud of 300 nCi/m^3 (non-occupational MPC$_a$) krypton-85 concentration. Thus, the gonad dose due to krypton-85 gamma emissions only is approximately 1 percent of the dose calculated using ICRP II methodology.

Estimates of the beta component of the gonad dose are tissue-depth dependent because of the attenuation of the beta particles and the bremsstrahlung produced; a typical value at a depth of 7 mg/cm^2 tissue, i.e., below the dead layer of skin, is 3 percent of the ICRP whole body dose (*21*). The 3 km, west sector genetically significant dose from NFS krypton-85 emissions in 1971 is thus bounded by 0.025 and 0.075 millirem, i.e., in the same range as the ICRP model tritium submersion dose. Because of the semi-infinite cloud model used, even these low calculated exposures are overestimates of the genetically significant submersion doses.

Inhalation doses

Inhalation doses at 3 km in the west sector were calculated for the particulates listed in table 3. Doses were calculated using the equation:

$$D_i = \Psi_{Kr}\,\frac{Q_i}{Q_{Kr}}\left(\frac{AD}{MPC_a}\right)_i \qquad \ldots (3)$$

where: D_i = the dose to the critical organ associated with the i$^{\text{th}}$ radionuclide listed in table 3,

Q_{Kr} = the year's release of krypton-85 in curies,

Q_i = the year's release of the i$^{\text{th}}$ radionuclide in curies,

$\left(\frac{AD}{MPC_a}\right)_i$ = the ratio of the ICRP annual dose (AD) in rem/year to the associated MPC$_a$ of the i$^{\text{th}}$ radionuclide in Ci-s/m^3, and

Ψ_{Kr} = the krypton exposure in table 4.

For each radionuclide, the inhalation dose was calculated as the dose to the organ for which the corresponding form of the radionuclide, soluble or insoluble, has the lowest MPC$_a$. The resultant inhalation doses were all very small and are listed in table 6.

Table 6. Inhalation doses
(West sector-3 km)

Isotope (form)	Critical organ	1971 dose (mrem/year)
Iodine-129 (Soluble)	Thyroid	9×10^{-4}
Strontium-89 (Soluble)	Bone	6×10^{-6}
Strontium-90 (Soluble)	Bone	7×10^{-4}
Ruthenium-106 (Insoluble)	Lung	7×10^{-5}
Cesium-134 (Insoluble)	Lung	2×10^{-5}
Cesium-137 (Insoluble)	Lung	2×10^{-6}
Tritium[a]	Whole body	2×10^{-2}

[a] Includes transpiration dose.

Iodine-129 in milk

Recent reports (*11,12*) have shown that milk taken from cows feeding on local stored feed around NFS contained measurable quantities of iodine-129. Concentrations ranged from 2 pCi/liter to 0.05 pCi/liter at distances of 1.5 to 7 miles from the plant. The measured concentrations decreased monotonically with distance.

It has not been possible to establish credible assumptions for a dose calculation for the milk

68

pathway. Although some milk is processed locally, most forms part of a large milk pool processed in the Buffalo, N.Y., area; some is processed in the New York City area. Because of this pooling with uncontaminated milk, the average concentration of iodine-129 in milk and milk products would be a small fraction of the observed values.

Several considerations influence a dose calculation, all of which are very uncertain. The number of persons drinking unpooled milk from local farms, if any, is unknown. The dose calculation would be related to the time intervals between depositions on individual pastures and weathering factors which remove it from foliage; these data are also unknown. Also, the time between deposition and feed storage is unknown. The lack of these and other factors precludes a credible dose calculation at this time.

Because of these significant findings, the New York State Department of Environmental Conservation will continue to evaluate the iodine-129 concentrations in milk even though the NFS plant is not processing fuel at the present time. Further, NFS is presently making plant modifications to assure significant in-plant iodine decontamination before effluents are released to the environment. These efforts should result in the reduction of iodine-129 impact to even lower levels.

Population dose due to milk ingestion is discussed below.

Water vectors

Ingestion doses

The Buttermilk-Cattaraugus Creek system constitutes a significant radionuclide vector to a *select* population in the vicinity of NFS. Various pathways include direct shine from the creek and radioisotopes on the creek banks, fish taken from the creek, and game animals whose prime water source is the creek. According to several reports (*1,5,6,22,23*) there are no potable water supplies served by the creek system; further, samples of crops partially irrigated with Cattaraugus Creek water show no crop uptake of NFS-associated radionuclides when compared to crops in other parts of New York State (*5,22*). Thus, the main water exposure vector to people is restricted to the immediate vicinity of the creek system and is of importance only to those few persons in intimate contact with it. Such individuals constitute the maximally exposed group.

The true impact of the creek system upon the population can be derived only from local demographic data which are presently insufficient for an accurate dose calculation. In recognition of this, and based partially upon the recommendations of Shleien (*1*), the EPA, with the cooperation of the New York State Department of Environmental Conservation, conducted an extensive survey of inhabitants (predominantly sportsmen) of the creek system from NFS to Lake Erie in 1971. Unfortunately, little of these data is available at this time.

Lacking complete demographic data and an officially accepted description of a "suitable" individual, a calculation of ingestion dose was made using reasonable consumption levels. The consumption levels assumed are listed in table 7. They are taken to be representative of the average of the maximally exposed population group.

Table 7. Estimated average yearly dietary intakes and exposure times for maximally exposed group

Media	Consumption or exposure time
Deer	4.8 kg
Fish	4.3 kg
Drinking water	0 liters
Air submersion	8,736 h
Creek bank occupancy	100 h

It is unlikely that any single individual will be found to have exactly the dietary intake and exposure time described in table 7. Preliminary demographic data clearly separate hunters and fishermen in the NFS area. In essence, those who fish in Cattaraugus Creek do not hunt and those who hunt would not fish in Cattaraugus Creek. On the other hand, there are both hunters and fishermen in the area and the data described in table 7 are an attempt to form a composite. For several reasons, the composite ignores intakes from other game animals, e.g., rabbits. There exist no small game consumption data for the area, and data on some small animals that inhabit the creek system (rabbits and raccoons) show no significant NFS-associated radionuclides (*3,23*) other than iodine-129 in thyroids which are not considered pathways to humans.

Deer meat consumption is based upon a preliminary analysis of the EPA demographic data (*24*); the 4.8-kg consumption listed in table 7 is 1/10 of the maximum found in the study and represents the median consumption; the mean consumption was about a factor of two lower. The assumed fish flesh consumption is one quarter of the 50 grams per day consumption reported (*25*) for commercial fishermen. The creek bank occupancy factor is based upon 1 hour per day occupancy of the bank during the summer months.

Average concentrations of radionuclides (*2,3,22*) in the foods in table 7 are listed in table 8. To the extent possible, doses were calculated only for NFS-associated vectors; fallout and natural background radiation were not included. Table 9 lists the dose conversion factors used to relate ingested activities to yearly dose (*1,15,16,26*). Table 10 lists the yearly doses to critical organs resulting from the ingested isotopes; this table also shows the equation used to calculate the yearly doses. The predominant ingestion pathway is fish taken from the creek.

Table 8. Average concentration of radionuclides in deer and fish flesh taken in the vicinity of NFS

Sampling vector	Radionuclide concentration (pCi/kg)				
	Cesium-137	Cesium-134	Cobalt-60	Strontium-90	Tritium
Deer [a]	945	252	49	15	—
Fish flesh [b]	3,500	1,100	—	470	28,000

[a] 14 samples from "1970 Annual Report of Environmental Radiation in New York State," and one sample from NFS Environmental Report No. 11 (*3*) 1971. Twelve deer taken onsite in 1970, two within the exclusion area.

[b] From NFS Environmental Reports Nos. 10 and 11 (*2,3*) for 1971. 17 suckers, 1 trout, all 6-inches long. Tritium levels assumed equal to Cattaraugus Creek tritium concentration near NFS; assumed reconcentration factor = 1. Concentration near Lake Erie could be lower by at least a factor of 5.

Table 9. Ingestion dose conversion factors [a]

Radionuclide	Critical organ	Dose conversion factor (rem/year per pCi intake)
Strontium-90	Bone	0.6×10^{-6}
Cesium-137	Whole body	$.06 \times 10^{-6}$
Cesium-134	Whole body	$.08 \times 10^{-6}$
Cobalt-60	G I tract	$.04 \times 10^{-6}$
Tritium	Whole body	$.13 \times 10^{-9}$

[a] Taken from Shleien (*1*).

Direct dose

The remaining significant water vector to be discussed is the direct dose from the radioisotopes in the creek. For the most part, these are bottom sediment radionuclides and are of significance only after having settled out and become exposed on the creek banks after periods of turbulent flow. Hot spots on the creek bank have been found annually during the late summer, the highest recorded exposure rate being 132 microroentgens per hour (*22,23*). These hot spots dissipate quickly and it is difficult to derive an average dose rate from them. An estimate of the average was made using the ratio of the average dose rate recorded at the NFS perimeter monitor (on Cattaraugus Creek) to the maximum dose rate recorded there for the year, this ratio being 0.22 (*2,3*). An upper estimate of the average exposure rate on the Cattaraugus Creek bank, then, is $0.22 \times 132 = 28$ microroentgens per hour. Using a quality factor of one, the creek shine dose for 100 hours per year occupancy is 2.8 millirem per year (whole body).

Population doses

Population dose (D_p) is the product of the population and the arithmetic average dose absorbed by that population. D_p has units of man-rem. Mathematically:

$$D_p = \sum_{i=1}^{N} \sum_{j=1}^{N} P_j \, D_i \, \delta_{ij} = N \, \bar{D} \begin{cases} \delta_{ij} = 1 \text{ for } i = j \\ \\ \delta_{ij} = 0 \text{ for } i \neq j \end{cases} \quad \ldots (4)$$

where:
N = the total population involved,
D_i = the dose absorbed by individual P_j in that population, and
δ_{ij} = the Kronecker delta, defined as shown above.

70

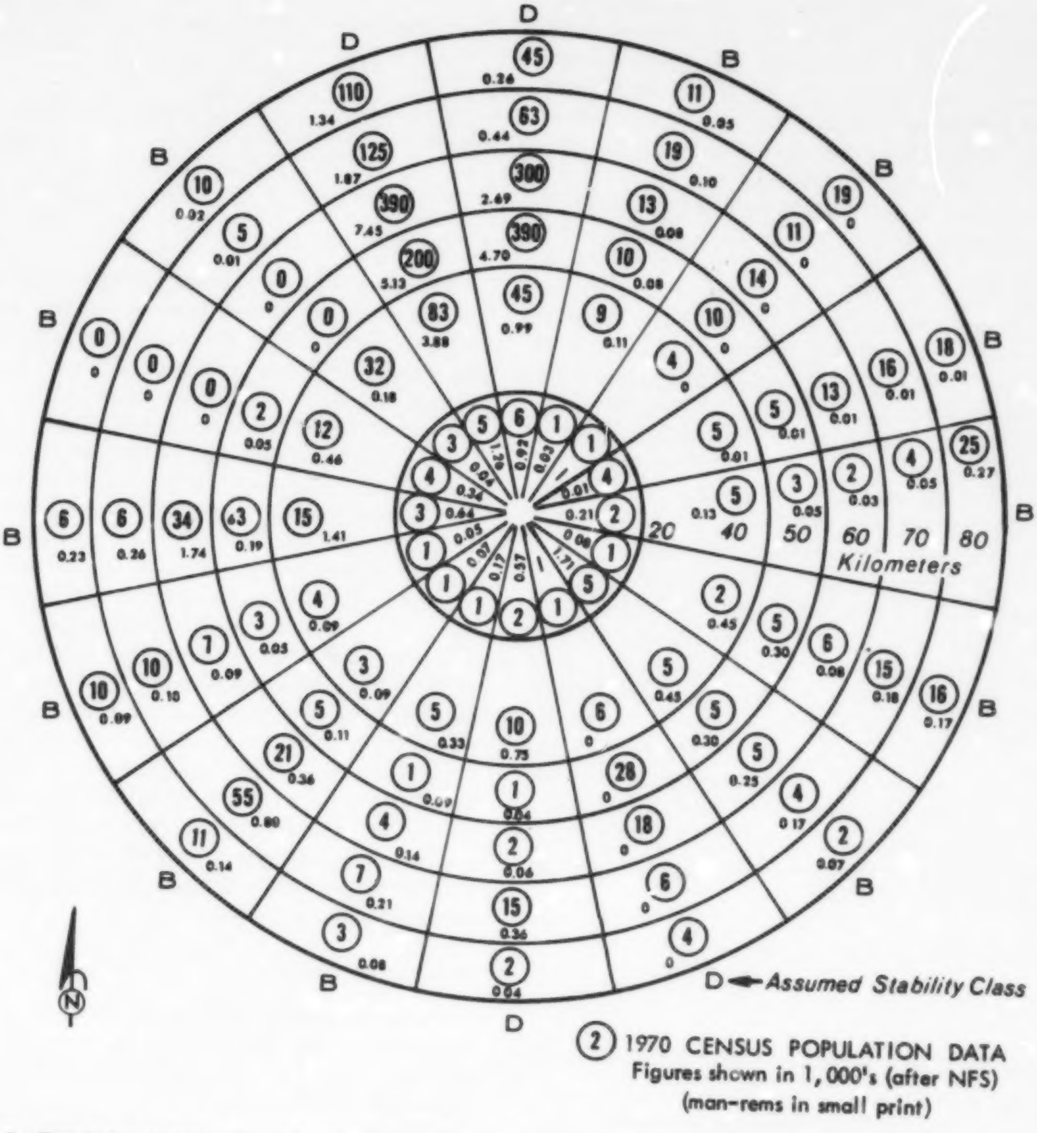
D
B
20
40
50
60
70
80
Kilometers
D ← Assumed Stability Class
② 1970 CENSUS POPULATION DATA
Figures shown in 1,000's (after NFS)
(man-rems in small print)

Figure 2. Population distribution and 1971 population skin doses by sector segment between 1 and 80 kilometers

Submersion population dose from the air pathway and ingestion population doses from the fish, deer, and water pathways were calculated. To put the matter into perspective, the submersion population dose due to natural background radiation for the two and one-half million people within 50 miles of the NFS plant is about 275,000 man-rem per year. All population doses due to NFS effluents were calculated to be many orders of magnitude lower than this.

Fifty-mile radius submersion population dose

The population dose from the airborne pathway was calculated for the case of submersion in a krypton-85 cloud. The population considered was that within a 50-mile radius of the NFS plant. The area around the plant was divided into 160 sector segments and populations within these sector segments were determined according to 1970 census figures as reported by NFS (*7,27*). The populations of small towns in the immediate vicinity of the plant were obtained from the Cattaraugus County Planning Department. The onsite population (zero to 1-mile radius) was not included in the calculation. The population distribution by sector segment is shown in figures 2 and 4.

The submersion population dose was calculated using the following equation:

$$D_p = \sum_{j=1}^{160} D_{pj} = 0.0526 \sum_{j=1}^{160} P_j \Psi_j \quad \ldots (5)$$

where: P_j = population in jth sector segment,

Ψ_j = ground level exposure of krypton-85 in jth sector segment in Ci-s/m^3,

D_{pj} = submersion population dose in in jth sector segment in man-rem/year, and

0.0526 = ratio of 0.5 rem/year to 9.5 Ci-s/m^3, i.e., a dose conversion factor derived from ICRP recommendations (*15*).

Ψ_j's for each sector segment were calculated from the data in tables 4 and 5, and figure 3, using equation 1. Table 4 gives the angular variation of Ψ at a radius of 3 kilometers. For any angle, the variation in Ψ with distance depends only upon distance and stability class. Accounting for distance variations is straight forward. The available information regarding stability classes is given in table 5. Stability classes for the 16 compass directions used in the calculation are shown in figure 2. The assumed stability classes roughly approximated the yearly average of the local meteorology in that cross-valley winds were assumed to be of class B stability with a 75 percent occurrence and axial valley winds were assumed to be of class D stability with a 25 percent occurrence.

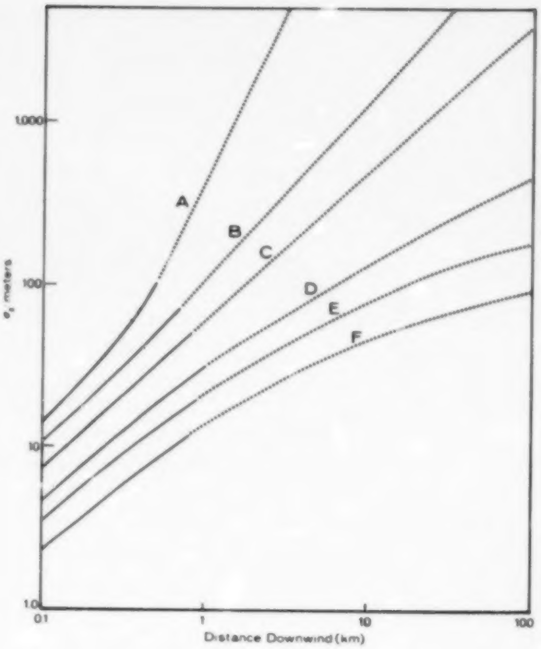

Figure 3. Vertical dispersion coefficient as a function of downwind distance from the source (Taken from EPA, Office of Air Programs Publ. AP-26) Letters A to F denote Pasquill stability classes; dashed portions of curves are less certain than solid portion.

Having defined the stability classes, the associated σ_z's at the midpoints of the sector segments were obtained from published data and are reproduced in figure 3 (*18*).

It was recognized that this calculational procedure left much to be desired. However, it was the best available technique and reflects the current state of the art. Calculations based upon equation 1 are to be considered "best estimates" only (*18*). Factor of two discrepancies between experiment and this theory are commonly found within a few miles of a source (*17,18*). Factor of 10 discrepancies have been found at greater distances (*17*).

An unpublished computer program, EXDOSE, was used to perform the calculations of equation 5. For the 12 sectors for which class B stability was assumed, a 1,300 meter capping layer was assumed, thereby limiting σ_z to a

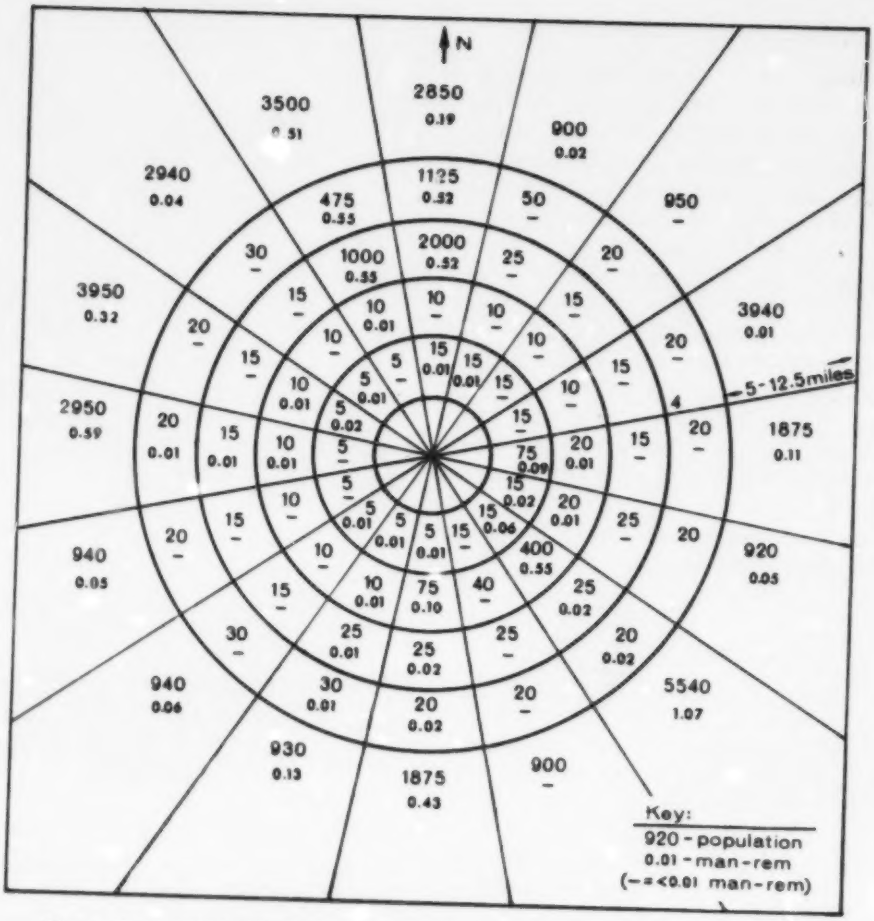
N
3500
0.51
2850
0.19
900
0.02
2940
0.04
475
0.55
1125
0.52
50
–
950
–
30
–
1000
0.55
2000
0.52
25
–
20
–
3950
0.32
15
–
10
0.01
10
–
10
–
15
–
3940
0.01
20
–
10
–
5
–
15
0.01
15
0.01
15
–
10
–
20
–
15
–
10
0.01
5
0.01
5
0.02
15
–
4
5-12.5miles
2950
0.59
20
0.01
15
0.01
10
0.01
5
–
75
0.09
20
0.01
15
–
20
–
1875
0.11
5
–
15
0.02
10
–
15
–
5
0.01
5
0.01
5
0.01
15
–
15
0.06
20
0.01
25
–
20
–
940
0.05
20
–
10
–
400
0.55
920
0.05
10
0.01
75
0.10
40
–
25
0.02
15
–
30
–
25
0.01
25
0.02
25
–
20
0.02
940
0.06
30
0.01
20
0.02
20
–
5540
1.07
930
0.13
1875
0.43
900
–
Key:
920 - population
0.01 - man-rem
(– = <0.01 man-rem)

Figure 4. Population distribution and 1971 population doses by sector-segments between 1 and 12.5 miles (1.6 to 20 kilometers)

maximum of 1,000 meters. This corresponds to the yearly average height of the capping layer for upper New York State (*28*). The population dose from krypton-85 submersion was calculated to be 46 man-rems (skin) due to NFS releases in 1971.

As noted previously, this submersion population dose is predominately a skin dose. The genetically significant (gonad) population dose averaged 2 percent of the skin population dose, or 1 man-rem. Figure 4 presents the in-close sector segment populations and population doses, and figure 5 illustrates the isodose contours.

Gross worldwide submersion population doses

Krypton-85 is one of the few long-lived radionuclides dispersed in significant quantities worldwide from the nuclear fuel cycle. A gross estimate of the worldwide population dose from krypton-85 submersion was obtained using a very simple atmospheric model. The equilibrium concentration of krypton-85 in the world due to NFS releases in 1971 is 2.21 × 10^5

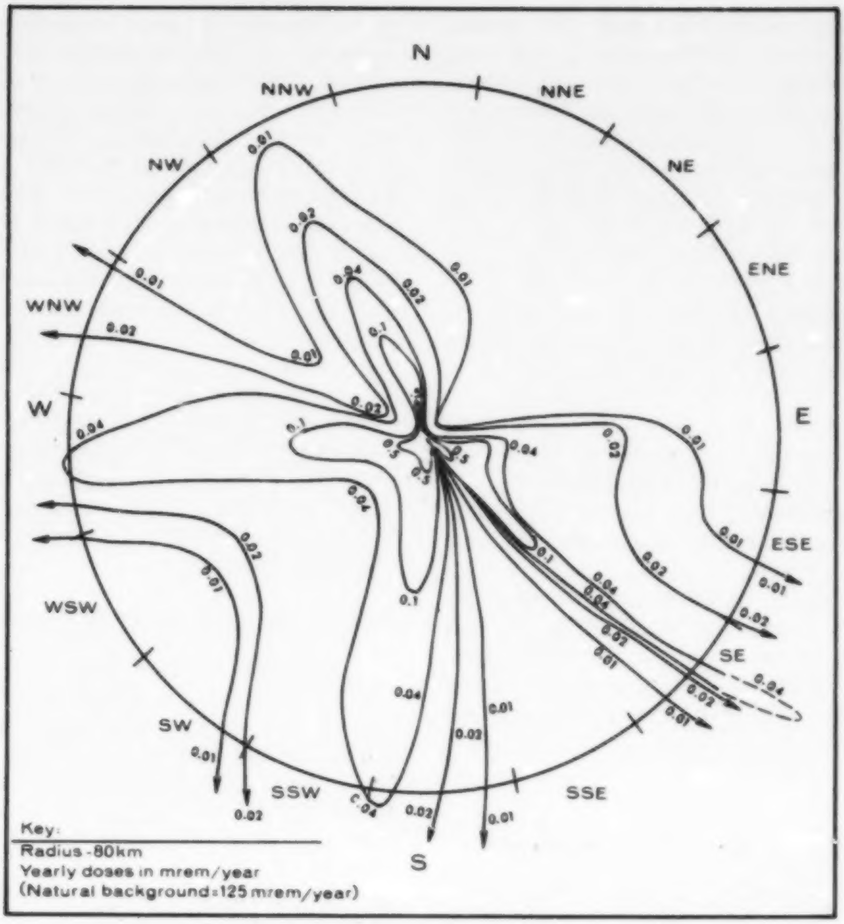
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
0.01
0.02
0.04
0.1
0.5
Key:
Radius-80km
Yearly doses in mrem/year
(Natural background=125 mrem/year)

Figure 5. Isodose contours for upper New York State from NFS krypton-85 releases in 1971 (Onsite meteorology during periods of release was used to propogate the krypton-85 throughout the region)

Ci/7.6 × 10^{18}m^3 = 2.9 × 10^{-14} Ci/m^3. At this concentration the skin dose (submersion) is 5 × 10^{-8} rem/year, assuming a uniform volumetric concentration. Since it is more reasonable to assume mixing to a constant mixing ratio (*29*), this dose should be about doubled to 10^{-7} rem/year. The total population in the world is about 3 × 10^{9} persons, resulting in a population dose of 300 man-rem/year (skin). The gonad population dose is about 2 percent of this or 6 man-rem/year. Knox and Peterson (*29*) estimate the dose commitment to be 16.1 times this yearly population dose, or about 100 man-rem (gonad) for a static population. The natural background induced population dose is about 4 × 10^{8} man-rem/year.

Population dose from ingestion of game

Population doses from the deer and fish ingestion pathways were obtained using an estimated ratio of the total yearly catch weight to the average weight consumed per person. This gives a reasonable estimate of the total number of persons involved in these pathways. Data for deer kills were obtained from questionnaires filled out by hunters reporting kills within a 20-mile radius of the NFS plant in 1970. (*24*). The total annual reported intake was 5.5 × 10^4 kg and the mean annual per capita venison consumption was 2.7 kg. Thus, the total population involved was 55,000/2.7 = 20,000 persons. Scaling the data in table 10, the whole body population dose from the ingestion of deer meat in 1971 was $0.4 \times 10^{-3} \times 20{,}000 \times 2.7/4.8 = 4.5$ man-rem, predominantly from cesium-134 and cesium-137. Other organ population doses appear in table 11. Since these data were calculated using average concentrations heavily weighted by onsite deer kills, they are probably overestimates by a considerable margin.

The demographic data required to adequately estimate the population dose from the fish pathway are not yet available. For this report, the results of a brief creel (fish basket) survey conducted by the New York State Department of Environmental Conservation were used (*30*). The survey was conducted over three weekdays and three weekends during July and August 1969. The daily and weekly averages were scaled up to 33 weeks, approximately the length of the fishing season. The pertinent data may be summarized as follows: 4,752 fish of 0.5 pound average weight were taken. Using the average concentration of 3,500 pCi/kg and dose conversion factor of 6 × 10^{-8} rem/year per pCi intake from tables 8 and 9, a whole body population dose of 0.23 man-rem was calculated for cesium-137 ingestion. As in other cases, this was rounded off to 0.2 man-rem. This and other organ population doses from fish ingestion are summarized in table 11. Since the average concentration used in the calculations was heavily weighted by fish caught between NFS and the nearby Springville Dam, these man-rem calculations also probably overestimate the dose by a considerable margin.

Table 10. Ingestion doses from deer and fish flesh

Radionuclide	Ingestion dose * (mrem/year)	Critical organ	Pathway dose (mrem/year)	
			Fish	Deer
Strontium-90	1.3	Bone	1.2	0.05
Cesium-134	.5	Whole body	.4	.10
Cesium-137	1.2	Whole body	.9	.3
Cobalt-60	.01	G I tract	ND	.01
Tritium	.015	Whole body	0.015	ND

* Dose = consumption (kg) × concentration (pCi/kg) × dose conversion factor $\frac{\text{(mrem/year)}}{\text{pCi}}$.

ND, nondetectable.

Table 11. Ingestion population doses

Radionuclide	Critical organ	Population dose (man-rem)	
		Fish	Deer
Strontium-90	Bone	0.3	0.5
Cesium-134	Whole body	.09	1.0
Cesium-137	Whole body	.2	3.5
Cobalt-60	G I tract	NA	.1
Tritium	Whole body	.004	NA

NA, not applicable.

Tritium ingestion population dose

The population dose from the ingestion of tritiated water was estimated for the populations served by municipal water intakes along the path of the effluents from NFS. Cattaraugus Creek flows into Lake Erie at Irving, N.Y. below Buffalo; the route to the sea is north and east through the Niagara River, Lake Ontario, and the St. Lawrence Seaway. Considered in the calculation was the population served by municipal water inlets between Irving, N.Y., U.S.A. and Cornwall, Ontario, Canada.

As noted earlier, no potable water is taken from Cattaraugus Creek. However, many municipalities derive some or all of their drinking water from large intake ports in the Great Lakes and St. Lawrence River. The mouths of these intake ports are intentionally located far from shore to avoid the sewage near the coastline. The stream flow-lines are complicated, making an exact calculation of dilution factors impossible in a practical sense.

Table 12 contains the significant data used in these calculations. Dilution factors for various locations along the water pathway were obtained by simply taking the ratio of volume flow rates of the appropriate streams. These dilution factors were applied to the yearly average tritium concentration (less back-

Table 12. Drinking water—ingestion pathway—population doses due to NFS tritium releases

Location	Population served (people)	Dilution means	Flow rate (feet ³/s)	Dilution factor	Average dose rate [b] (mrem/year)	Population dose (man-rem/year)
Confluence of Buttermilk and Cattaraugus Creeks [a]	—	Cattaraugus Creek	358	1.0	—	—
Lake Erie	1.35×10^6	Niagara River	195,000	1.9×10^{-3}	4.5×10^{-3}	5
Lake Ontario	2.9×10^6	St. Lawrence River	240,000	1.5×10^{-3}	3.6×10^{-3}	10
International portion of St. Lawrence River	0.2×10^6	St. Lawrence River	240,000	1.5×10^{-3}	3.6×10^{-3}	0.7
Total	4.5×10^6					16

[a] No potable water taken from Cattaraugus Creek. Yearly average (1971) tritium concentration in Cattaraugus Creek at confluence with Buttermilk Creek = 2.8×10^{-5} μCi/ml.

[b] Average dose rate $= 2.8\times10^{-5}$ μCi/ml × dilution factor × $\frac{500 \text{ mrem/year}}{6\times10^{-3}\ \mu\text{Ci/ml}}$

References: (1). NFS Environmental Report No. 11.

(2). Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River; International Joint Commission—Canada and United States, A. D. P. Heeney and S. A. Herter, Jr., cochairmen. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1970).

ground) observed in 1971 in the Cattaraugus Creek at the NFS site boundary. Doses were calculated using an ICRP whole body dose conversion factor assuming 1.1 liter per day average consumption of water from these sources; the equation is given in table 12. Except for Lake Erie, the tabled populations are those served by the municipal intake ports (*31*). For Lake Erie, the population is that of Erie and Niagara counties—although many communities undoubtedly obtain their drinking water from inland water supplies.

To place this data in its proper context, the tritium induced 16 man-rem may be compared to the ca. 540,000 man-rem accumulated from natural background radiation by the combined population.

Thyroid population dose from milk ingestion

The thyroid population dose due to the consumption of milk and milk products containing iodine-129 released from the NFS plant was estimated using certain credible assumptions. The basic assumption is that all of the milk and milk products are consumed by humans at some time. Because of the dilution of the local iodine-129 contaminated milk by uncontaminated milk in large milk pools, the average dose and the population are uncertain. However, the man-rem product is insensitive to such lack of information.

For the calculation, the average concentration of iodine-129 in the undiluted milk pool must be estimated. For this estimate, the data of Magno, et al. (*11*), obtained to corroborate the initial N.Y. State measurements (*12*), were used. The data are shown in figure 6. An easily integrable, good fit to the data is given by the expression:

$$c(r) = 2.7 \exp(-r/2) = 2.7 \exp{-\lambda r}.$$

The average concentration, $\bar{c}$, in the milk pool out to a radius R_o from the NFS stack is:

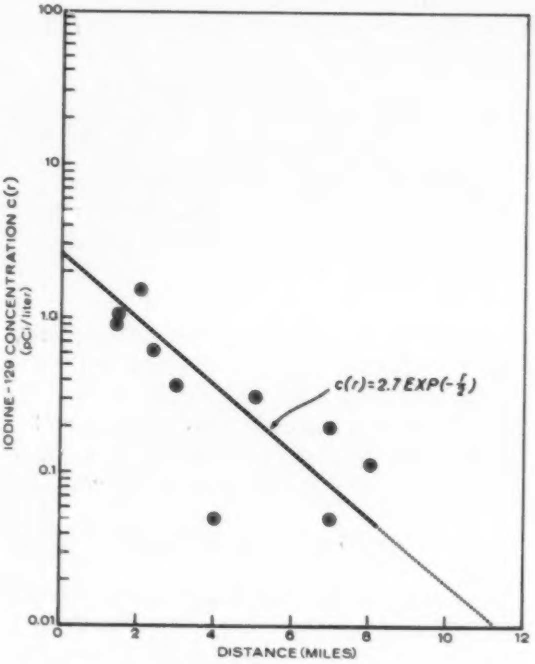

Figure 6. Iodine-129 concentration in milk, NFS environs, fall-winter 1971

$$\bar{c} = \frac{\int_0^{2\pi}\int_0^{R_o} c(r,\theta)\ \sigma\ (r,\theta)\ r\ dr\ d\theta}{\int_0^{2\pi}\int_0^{R_o} \sigma\ (r,\theta)\ r\ dr\ d\theta} \qquad \ldots (6)$$

where $\sigma\ (r,\theta)$ is the volume of milk produced per unit area at distance r and angle θ about the NFS plant. According to NFS (*7*), the milk pool within 25 miles of the NFS plant is about 500,000 liters/day and this milk-producing area is heavily and rather uniformly populated by cows. For calculational purposes, it is assumed that $c(r,\theta) = c(r)$ and $\sigma\ (r,\theta) =$ constant. Under these assumptions:

$$\bar{c} \approx \frac{2\pi\int_0^{R_o} c(r)\ r\ dr}{\int_0^{R_o} 2\ \pi\ r\ dr} \approx \frac{5.4}{R_0^2\lambda^2} \approx 0.035\ \text{pCi/liter} \qquad \ldots (7)$$

where terms of the order exp (−12.5) have been ignored and $R_o = 25$ miles.

Having $\bar{c}$, the population dose for a population like the ICRP standard man is:

$D_p =$ (curies intake) (rem/curie) (population)

$$\approx \left[\bar{c}\,(\text{pCi/liter})\ \frac{1}{f}\,\bar{v}\ \ (\text{liter/d})\ \frac{365\text{d}}{2}\right] \left[\frac{30\ \text{rem/year}}{\text{MPC}_w\ (\text{pCi/liter})\ \ 2.2\,(\text{liter/d})\ \ 365\,(\text{d})}\right] \left[\frac{(f)500{,}000\ (\text{liter/d})}{\bar{v}\,(\text{liter/d-person})}\right] \qquad \ldots (8)$$

where f is the dilution factor provided by other milk in the pool, $\bar{v}$ is the average daily consumption of milk and milk products, and the time involved is one-half year, approximately the time the cows were on stored feed. Using $\text{MPC}_w = 4 \times 10^{-6}\ \mu\text{Ci/ml} = 4$ nCi/liter:

$$D_p \approx 30\ \text{man-rem (thyroid)}$$

Neglected in the foregoing is the smaller average mass of the child's thyroid. Zero to 1-year-old children compose slightly less than 3 percent of the total population (*27*) and their thyroid masses average about one-tenth that of the standard man (*16*). Partially offsetting the higher potential dose due to the smaller thyroid is a smaller uptake fraction in the child's body. Overall for a given intake, the child's iodine-129 thyroid dose would be about a factor of 2 greater than that of a standard man (*32,33*). The inclusion of these factors would increase D_p as calculated above by a factor of about 1.06. Since the uncertainty of this factor is less than other uncertainties in this calculation, this correction was not made.

Conclusion and recommendations

The public documentation regarding the NFS facility operations and effluents is extensive, providing a ready, if bulky, record whereby source terms, vectors, and pathways to the exposed population can be determined. Meteorological and demographic data required for a full assessment of population dose are not as readily available. Site specific definitions of the habits of suitable sample(s) of the population, e.g., occupancy factors and consumption intakes along pathways, are virtually nonexistent, leaving much to the discretion of the individual investigator. For the NFS facility, doses to the average individual in the maximally exposed population groups were calculated using reasonable estimates of demographic factors, partially based upon EPA and New York State data.

Although many pathways to man have been considered in the foregoing, many have not. The obvious ones and some obscure ones have been considered. All of the major effluents reported by the NFS facility have been considered. Although there may be unknown pathways along which very high reconcentration factors are operable, all known ones have been analyzed herein. In the light of the intensive surveillance of the facility by many agencies, public and private, it is likely that all major pathways have been considered. Specifically not considered, however, were the very long range effects due to recycling of long-lived radionuclides, such as iodine-129 and tritium, in the troposhere.

All of the effluents and individual exposures resulting from the operation of NFS have been within the existing governmental regulations for effluents and exposures. Continuous indepth surveillance by all involved parties has provided warnings leading to corrective actions in advance of any effluent by any pathway becoming a problem to the local population.

Based upon the analyses performed in this study, certain recommendations can be made. These are listed below without regard to cost-effectiveness or preferential order, and ignoring the already low impact of the NFS facility upon the local population.

1. The NFS plant should run its full iodine treatment system routinely, regardless of the decay of iodine-131. Iodine-129 appears in significant quantities in indicator pathways (i.e., animal thyroids) and in measurable quantities in milk; such buildup should be curtailed now.

2. Iodine-129 surveillance should be intensified. Measurement of the decontamination factor of the new NFS iodine treatment system should be given highest priority in the environmental surveillance program when the NFS plant begins new operations.

3. Surveillance of the Cattaraugus Creek system by New York State should be continued to determine whether the NFS liquid waste treatment plant is making progress in reducing radionuclide effluents.

4. Krypton-85 concentration data for the hills to the west of the NFS facility should be obtained. Although meteorological models predict little dose, the models are uncertain enough to require verification.

5. Site specific descriptions of suitable samples of the population (e.g., occupancy factors and ingestion data) should be promulgated for all nuclear facilities. These descriptions should be amenable to orderly change.

Acknowledgment

Personal thanks are expressed to the following: Messrs. Bill Nixon and Bill Ray, Irradiated Fuels Branch, U.S. Atomic Energy Commission and Messrs. Tom Cashman and Bill Kelleher, New York State Department of Environmental Conservation for providing selected data and reports; to the latter for suggesting the tritium population dose calculation; Messrs. Paul Magno and Joe Cochran of the ORP Field Operations Branch and Jack Russell of the Technology Assessment Division, ORP, for several long illuminating discussions; Dr. Jerry Swift of ORP for a critical manuscript review; and Harry Calley, Chief, Operations Analysis Branch, ORP, for guidance and direction in the early stages of this study.

REFERENCES

(*1*) SHLEIEN, B. An estimate of radiation doses received by individuals in the vicinity of a nuclear fuel reprocessing plant in 1968, BRH/NERHL 70–1 (May 1970). PHS, Bureau of Radiological Health, Rockville, Md. 20852.

(*2*) WILCOX, D. P. and T. K. WENSTRAND. Environmental Report No. 10, January-June 1971. Nuclear Fuel Services, Inc., West Valley, N.Y.

(*3*) WENSTRAND, T. K. and D. P. WILCOX. Environmental Report No. 11, July-December 1971. Nuclear Fuel Services Inc., West Valley, N.Y. (February 2[illegible], 1972).

(*4*) ATOMIC ENERGY COMMISSION. Nuclear Fuel Services, Inc., AEC Docket No. 50–201. Available for public perusal at AEC Public Document Room, Washington, D.C. 20545.

(*5*) RUNION, T. C. Environmental effects of producing nuclear power, Hearings before the Joint Congress on Atomic Energy, February 24–26, 1970, Volume 1, Part 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 pp. 1697–1731.

(*6*) LOGSDON, J. E. and J. W. N. HICKEY. Radioactive waste discharges to the environment from a nuclear fuel reprocessing plant. Radiol Health Data Rep 12: 305–312 (June 1971).

(*7*) MILLER, R. N. Environmental Report, Fuels Fabrication Plant, West Valley, N.Y., U.S. AEC Docket No. 70–1292 (December 1971).

(*8*) ATOMIC ENERGY CLEARING HOUSE. Volume 16, No. 29 (August 20, 1970) pp. 3–7. Congressional Information Bureau, Inc., Washington D.C. 20005.

(*9*) COCHRAN, J. A., D. G. SMITH, P. J. MAGNO, and B. SHLEIEN. An investigation of airborne radioactive effluent from an operating nuclear fuel reprocessing plant, BRH/NERHL 70–3. (July 1970).

(*10*) RUSSELL, J. L. and P. B. HAHN. Public health aspects of iodine-129 from the nuclear power industry. Radiol Health Data Rep 12:189–194 (April 1971).

(*11*) MAGNO, P. J., T. C. REAVEY, and J. C. APIDIANAKIS. Iodine-129 in the environment around a nuclear fuel reprocessing plant, ORP/SID 72–5. EPA, Office of Radiation Programs, Rockville, Md. 20852 (October 1972).

(*12*) BENTLEY, W. 1971 annual report of environmental radiation in New York State. State of New York, Department of Environmental Conservation, Albany, N.Y. (July 7, 1972).

(*13*) GRIFFIN, W. R., J. A. COCHRAN, and A. A. BERTUCCIO. A sampler for non-aqueous tritium gases. EPA, Northeastern Radiological Health Laboratory, Winchester, Mass. 01890.

(*14*) COCHRAN, J. A., W. R. GRIFFIN, and E. J. TROIANELLO. The observation of airborne tritium as a source and environmental waste discharge from a nuclear fuel reprocessing plant. To be published as EPA/ORP 73–1. EPA, Northeastern Radiological Health Laboratory, Winchester, Mass. 01890.

(*15*) INTERNATIONAL COMMITTEE ON RADIOLOGICAL PROTECTION. Report of Committee II on permissible dose for international radiation (1959). Pergamon Press, New York, N. Y.

(*16*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1 (May 13, 1960); Report No. 2 (September 1961); and Report No. 7 (May 1965). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*17*) ATOMIC ENERGY COMMISSION. Meteorology and atomic energy, 1968, equation 3.144, TID-24190. National Technical Information Service, Springfield, Va. 22151 p. 113.

(*18*) TURNER, D. B. Workbook of atmospheric dispersion estimates, AP-26 (1970 Revision). EPA, Office of Air Programs, Research Triangle Park, N.C. 27709. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*19*) ATOMIC ENERGY COMMISSION. Record memorandum placed in AEC Docket 50-201 file of telecon between W. H. Ray, Irradiated Fuels Branch, AEC, and Dr. E. D. North, Nuclear Fuel Services on April 7, 1972. AEC Public Document Room, Washington, D.C. 20545.

(*20*) ATOMIC ENERGY COMMISSION. AEC safety guide #3, assumptions used for evaluating the potential radiological consequences of a loss of coolant accident for boiling water reactors (November 2, 1970). Director, Division of Reactor Standards, AEC, Washington, D.C. 20545.

(*21*) RUSSELL, J. L. and F. L. GALPIN. Comparison of techniques for calculating doses to the whole body and to the lungs from radioactive noble gases. Presented at Topical Symposium of Health Physics Society, Richland, Wash., 99352 (November 1971).

(*22*) BENTLEY, W. E. Annual reports of environmental radiation in New York State, 1969 and 1970. State of New York, Department of Environmental Conservation, Albany, N.Y. (December 1, 1970 and June 18, 1971).

(*23*) DEPARTMENT OF ENVIRONMENTAL CONSERVATION. Environmental radiation bulletins quarterly. State of New York, Department of Environmental Conservation, Albany, New York.

(*24*) PETERSON, Jr., H. T. Estimation of vension consumption patterns in deer-hunter households, draft (April 13, 1972). EPA, Technology Assessment Division, Office of Radiation Programs, Rockville, Md. 20852.

(*25*) COWSER, K. E. and W. S. SNYDER. Safety analysis of radionuclides released to the Clinch River, ORNL-3721, Supplement 3 (1966). Oak Ridge National Laboratory, Oak Ridge, Tenn.

(*26*) SHLEIEN, B. An evaluation of internal radiation exposure based upon dose committments from radionuclides in milk, food, and air. Health Phys 18:267-275 (1970).

(*27*) BUREAU OF CENSUS. 1970 census of population, Volume 1, number of inhabitants by State, U.S. summary and Series PC(1)-A. Distribution Section, Bureau of Census, Department of Commerce, Washington, D.C. 20233.

(*28*) HOLZWORTH, G. C. Mixing heights, wind speeds, and potential for urban air pollution throughout the contiguous United States. EPA, Office of Air Programs, Research Triangle Park, N. C. 27709.

(*29*) KNOX, J. B. and K. R. PETERSON. Estimates of dose to Northern Hemisphere population groups from Kr-85 emitted by a single nuclear fuel reprocessing plant. Nucl Safety 13:130-135 (March-April 1972).

(30) ANDERSON, K. Creel survey, Cattaraugus Creek, 1969. New York State Department of Environmental Pollution Control, Bureau of Radiation Pollution Control, Albany, N.Y. (March 6, 1970).

(*31*) HEENEY, A. D. P. and C. A. HERTER, Jr., Co-Chairman. Pollution of Lake Erie, Lake Ontario and the International Section of the St. Lawrence River (1970). International Joint Commission, Canada and the United States. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*32*) BRYANT, P. M. Data for assessments concerning controlled and accidental releases of ^{131}I and ^{137}Cs to atmosphere. Health Phys 17:51 (1969).

(*33*) BRYANT, P. M. Derivation of working limits for continuous release rates of ^{129}I to the atmosphere. Health Phys 19:611 (1970).

BIBLIOGRAPHY

MAGNO, P., T. REAVEY, and J. APIDIANAKIS. Liquid waste effluents from a nuclear fuel reprocessing plant, BRH/NERHL 70-2. PHS, Bureau of Radiological Health, Rockville, Md. 20852 (November 1970).

SAX, N. I. et al. Radioecological surveillance of the waterways around a nuclear fuels reprocessing plant. Radiol Health Data Rep 10:289-296 (July 1969).

KELLEHER, W. J. Environmental surveillance around a nuclear fuel reprocessing installation, 1965-1967. Radiol Health Data Rep 10:329-339 (August 1969).

ATOMIC ENERGY COMMISSION. Environmental measurements around the Nuclear Fuel Services, Inc., fuel reprocessing plant. Independent Measurements Program, Division of Compliance, AEC, Idaho Operations Office, Idaho Falls, Idaho.

KIRK, W. P. Krypton-85—a review of the literature and an analysis of radiation hazards. EPA, Eastern Environmental Radiation Laboratory, P. O. Box 61, Montgomery, Ala. 36101 (January 1972).

FOWLER, T. W. and D. E. VOIT. A review of the radiological and environmental aspects of krypton-85, NF-69-16. PHS, Bureau of Radiological Health, Rockville, Md. 20852 (September 1969) Revised June 1970.

HENDRICKSON, M. N. The dose from Kr-85 released to the earth's atmosphere, BNWL-SA-3233, IAEA-SM-146/12. Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Wash. 99352 (July 1970).

COLEMAN, J. R. and R. LIBERACE. Nuclear power production and estimated krypton-85 levels. Radiol Health Data Rep 7:615-621 (November 1966).

ATOMIC ENERGY COMMISSION. Technical statement containing a summary description of the facility and the features important to safety, AEC Docket No. 50-201. Nuclear Fuel Services, Inc. West Valley, N. Y. (Docketed February 8, 1963).

OAK RIDGE NATIONAL LABORATORY. Siting of fuel reprocessing plants and waste management facilities, ORNL-4451 (July 1971). Oak Ridge National Laboratory, Oak Ridge, Tenn. Available from National Technical Information Service, Springfield, Va. 22151.

RUSSELL, J. L. A review of the actual and the projected offsite doses at fuel reprocessing plants (May 1972). EPA, Office of Radiation Programs, Rockville, Md. 20852.

Assessment of Doses in the Western United States from the People's Republic of China Nuclear Test of January 7, 1972

R. B. Evans, R. N. Snelling, and F. N. Buck[1]

Measurable increases in airborne radioactivity were detected in the western United States by the Air Surveillance Network (operated by the National Environmental Research Center-Las Vegas, EPA) following a nuclear detonation by the People's Republic of China on January 7, 1972. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 1.2 mrem at Pueblo, Colorado.

The U.S. Atomic Energy Commission has announced that the People's Republic of China detonated a nuclear device with a yield of less than 20 kilotons at its Lop Nor testing ground at approximately 2:00 a.m. e.s.t. on January 7, 1972 (*1*). Measurable increases in airborne radioactivity were subsequently detected in the western United States by the Air Surveillance Network (ASN) beginning January 10, 1972. The network, operated by the Environmental Protection Agency, National Environmental Research Center-Las Vegas, presently includes air sampling stations in 21 western States.[2] During January 1972, 103 routine stations of the ASN were operated continuously. In addition, 10 standby stations were operating (in a routine test) during most of the period, January 10 to 25, 1972.

A gross beta concentration of 2 pCi/m^3 above background first was observed in a sample collected January 10 at Bryce Canyon, Utah. The highest concentrations ultimately were found in samples from Wyoming, Colorado, Idaho, and Utah (*2*).

The highest hypothetical infant thyroid dose equivalent resulting from inhalation of iodine-131 and tellurium-132 was about 1.2 mrem at Pueblo, Colo. (*3*). The highest hypothetical infant thyroid ingestion dose equivalent estimated from concentrations of iodine-131 in milk was about 10 mrem at Laramie, Wyo. The Federal Radiation Council has recommended that the average radiation dose to the thyroids of a suitable sample of the general population be kept below 500 mrem per year. The inhalation dose equivalent of 1.2 mrem calculated for Pueblo, Colo., is about two-tenths of 1 percent of this guide. The hypothetical ingestion dose calculated for Laramie, Wyo. is about 2 percent of this guide (*4*).

Gross beta concentrations

Ten sampling stations were selected at random for a determination of background gross

---

[1] National Environmental Research Center-Las Vegas, U.S. Environmental Protection Agency, Las Vegas, Nev. 89114. At the time this work was performed, the Center was named the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding, No. AT(26-1)-539 with the Nevada Operations Office, U.S. Atomic Energy Commission. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

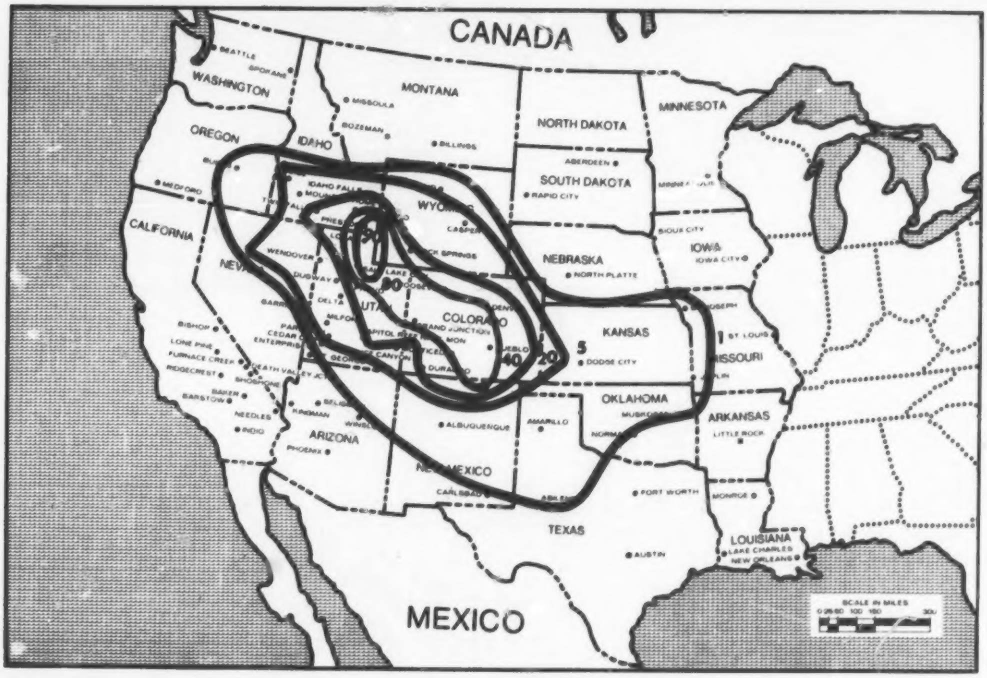
CANADA
WASHINGTON
MONTANA
OREGON
IDAHO
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MEXICO
80
40
20
5
1
SCALE IN MILES

Figure 1. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 13, 1972

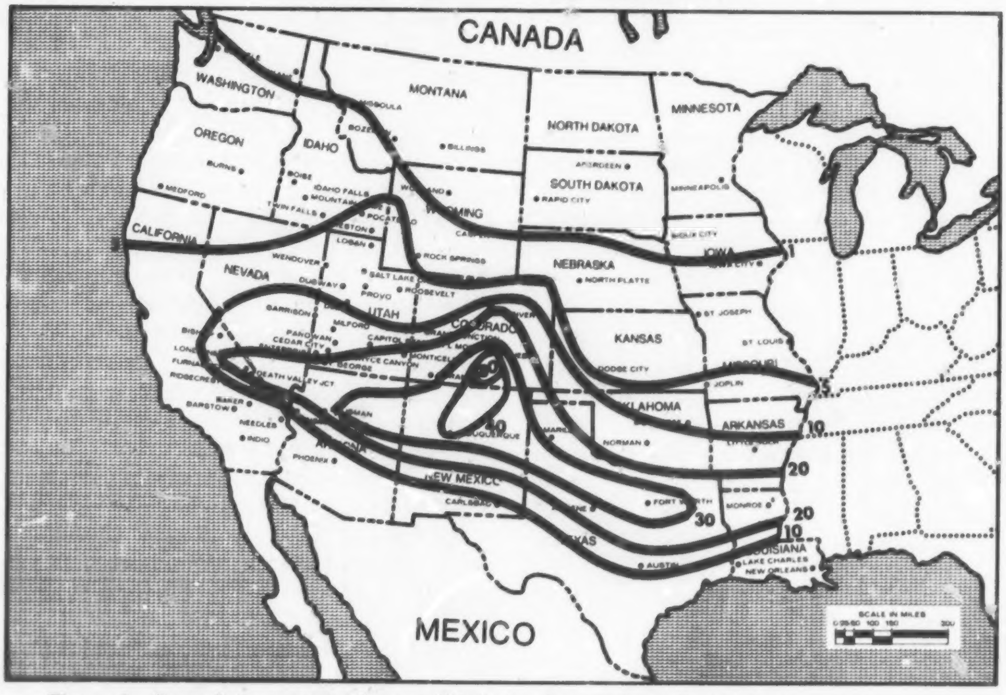
CANADA
WASHINGTON
MONTANA
OREGON
IDAHO
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
CALIFORNIA
NEBRASKA
IOWA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
MEXICO
1
5
10
20
20
10
30
40
60
SCALE IN MILES

Figure 2. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 14, 1972

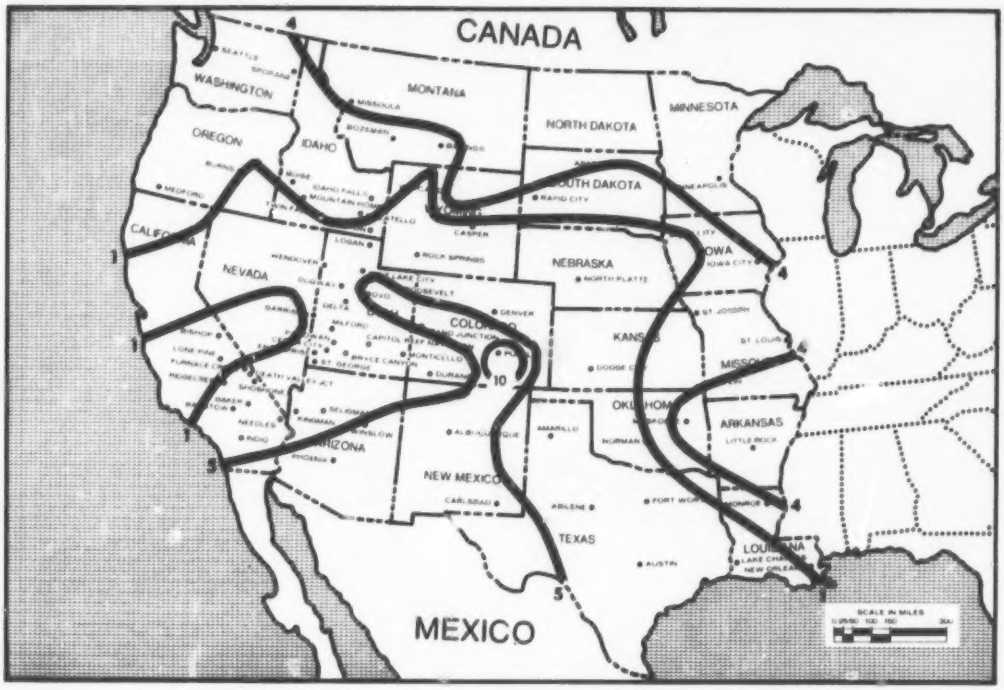
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
CALIFORNIA
NEVADA
NEBRASKA
IOWA
KANSAS
COLORADO
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
SCALE IN MILES
4
1
1
1
5
10
4
4
4
5

Figure 3. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 16, 1972

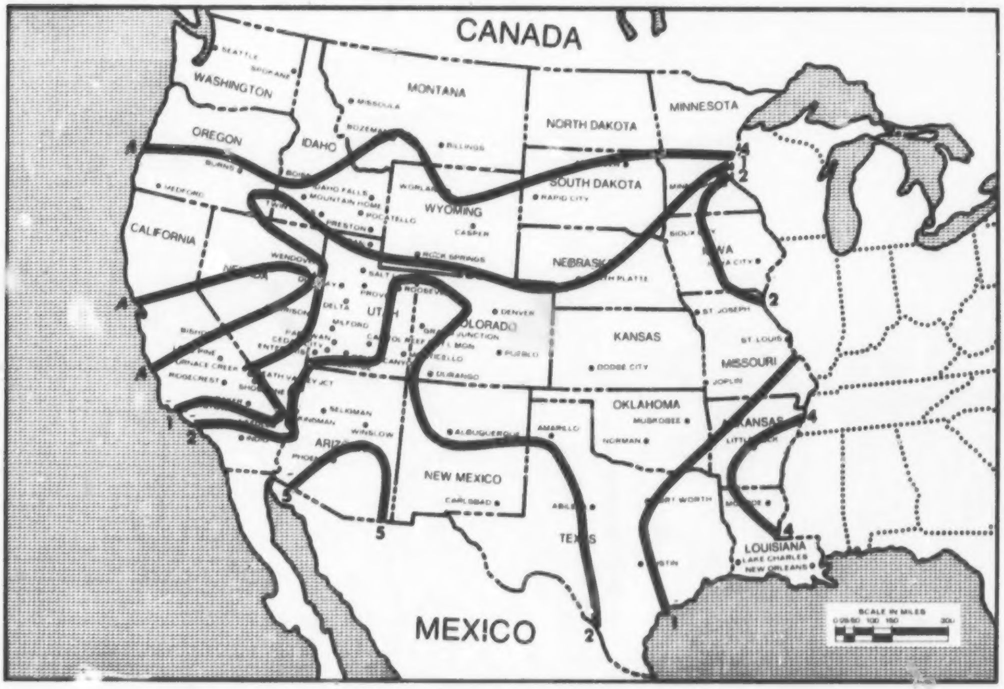
CANADA
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WYOMING
CALIFORNIA
NEVADA
UTAH
NEBRASKA
IOWA
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
ARIZONA
NEW MEXICO
TEXAS
LOUISIANA
MEXICO
SCALE IN MILES
4
4
4
1
2
4
2
2
4
4
5
5
2
1

Figure 4. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 18, 1972

82

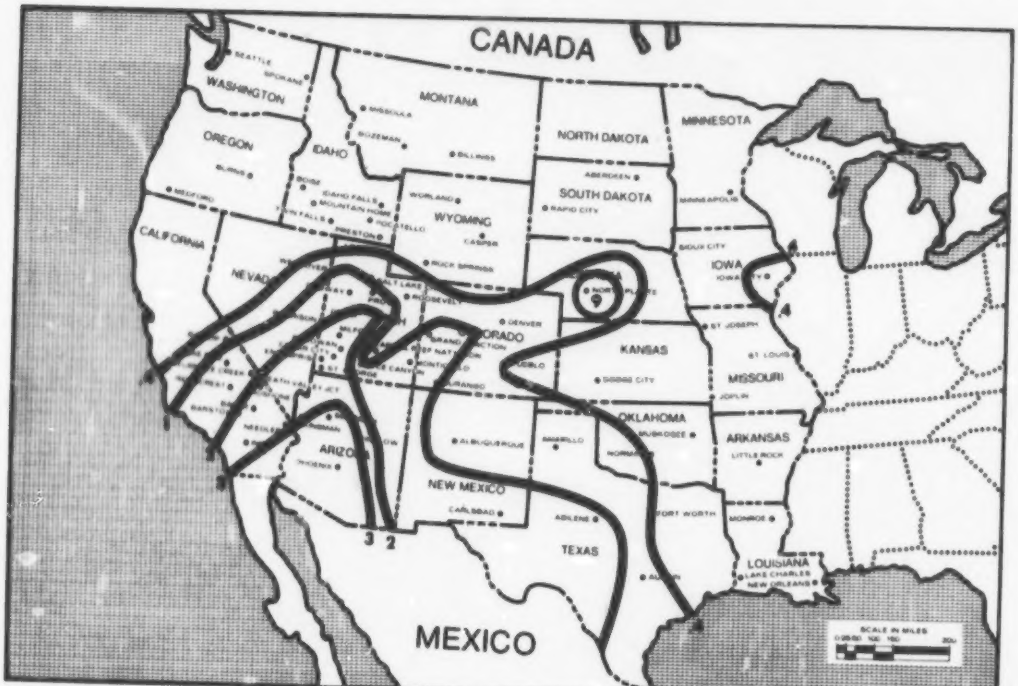
CANADA
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNESOTA
MINNEAPOLIS
CALIFORNIA
NEVADA
SALT LAKE
ROOSEVELT
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
ST JOSEPH
ST LOUIS
MISSOURI
JOPLIN
OKLAHOMA
MUSKOGEE
NORMAN
AMARILLO
ARKANSAS
LITTLE ROCK
ARIZONA
PHOENIX
NEEDLES
ALBUQUERQUE
NEW MEXICO
CARLSBAD
ABILENE
FORT WORTH
TEXAS
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
3
2
1
SCALE IN MILES

Figure 5. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 20, 1972

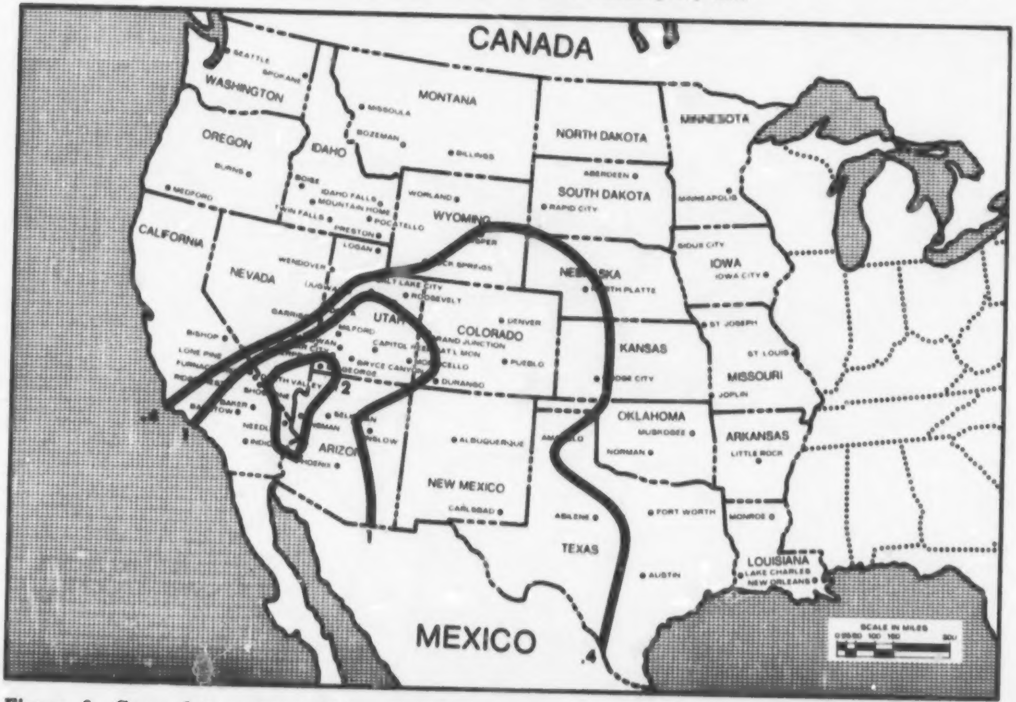
CANADA
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
LOGAN
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNESOTA
MINNEAPOLIS
CALIFORNIA
BISHOP
LONE PINE
NEVADA
WENDOVER
SALT LAKE CITY
ROOSEVELT
UTAH
MILFORD
CAPITOL REEF
BRYCE CANYON
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
NEBRASKA
NORTH PLATTE
IOWA
SIOUX CITY
IOWA CITY
KANSAS
DODGE CITY
ST JOSEPH
ST LOUIS
MISSOURI
JOPLIN
OKLAHOMA
MUSKOGEE
NORMAN
AMARILLO
ARKANSAS
LITTLE ROCK
ARIZONA
PHOENIX
WINSLOW
NEEDLES
BARSTOW
ALBUQUERQUE
NEW MEXICO
CARLSBAD
ABILENE
FORT WORTH
TEXAS
AUSTIN
MONROE
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
2
1
.4
SCALE IN MILES

Figure 6. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 22, 1972

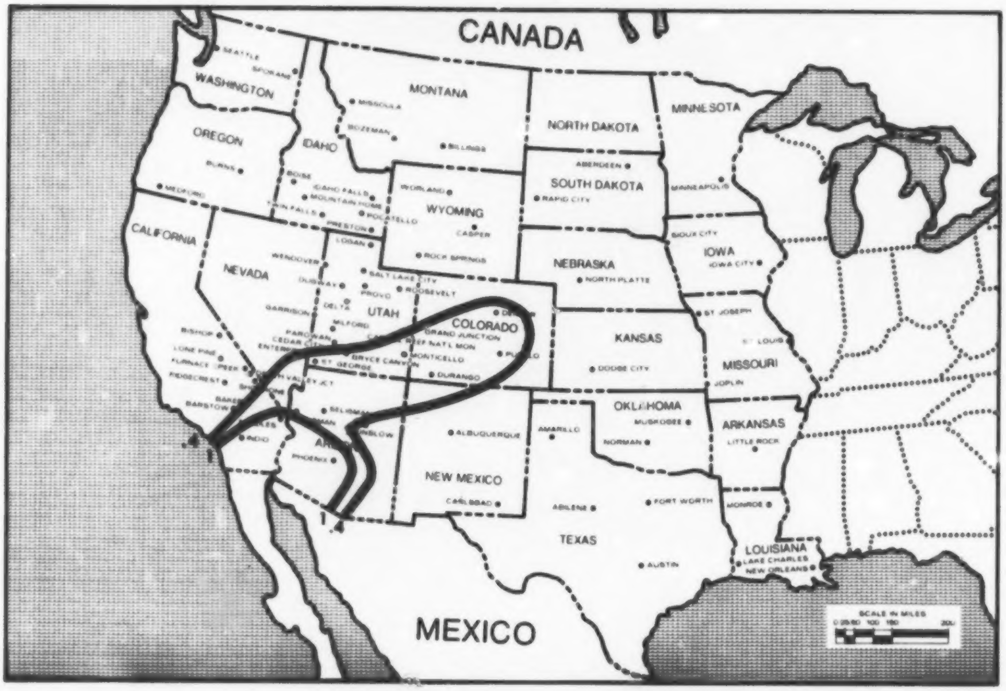
CANADA
WASHINGTON
SEATTLE
SPOKANE
MONTANA
MISSOULA
BOZEMAN
BILLINGS
NORTH DAKOTA
MINNESOTA
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
WORLAND
WYOMING
CASPER
ROCK SPRINGS
SOUTH DAKOTA
ABERDEEN
RAPID CITY
MINNEAPOLIS
CALIFORNIA
NEVADA
WENDOVER
LOGAN
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
UTAH
GARRISON
MILFORD
PAROWAN
CEDAR CITY
BRYCE CANYON
ST GEORGE
COLORADO
GRAND JUNCTION
MONTICELLO
DURANGO
PUEBLO
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
BARSTOW
NEBRASKA
NORTH PLATTE
SIOUX CITY
IOWA
IOWA CITY
ST JOSEPH
KANSAS
DODGE CITY
ST LOUIS
MISSOURI
JOPLIN
OKLAHOMA
MUSKOGEE
NORMAN
ARKANSAS
LITTLE ROCK
AMARILLO
ALBUQUERQUE
NEW MEXICO
CARLSBAD
PHOENIX
WINSLOW
SELIGMAN
ABILENE
FORT WORTH
MONROE
TEXAS
AUSTIN
LOUISIANA
LAKE CHARLES
NEW ORLEANS
MEXICO
SCALE IN MILES
.4
1
1
.4

Figure 7. Gross beta concentrations (pCi/m³) in air samples collected during a 24-hour period ending 1200 local standard time, January 24, 1972

beta concentrations for the first 12 days of January. Values less than the minimum detectable concentration were ignored, thus raising the estimate of the average. The average gross beta concentration was found to be 0.14 pCi/m³ with an average standard deviation of 0.06 pCi/m³. For the purpose of detecting the presence of airborne radioactivity, values greater than 3-standard deviations above background (i.e., total gross beta concentration greater than 0.32 pCi/m³) were considered to be significant. Because gross beta results are reported to the nearest 0.1 pCi/m³, a gross beta concentration equal to or greater than 0.4 pCi/m³ was assumed to represent a departure from background.

Gross beta air sampling results are plotted in figures 1 through 7. By January 25th, airborne radioactivity was no longer detectable.

Composition of airborne radioactivity

Gross beta concentrations above background were measurable at 102 routine and 10 standby ASN stations. A total of 108 stations showed concentrations high enough to allow quantitation of specific isotopes by gamma spectroscopy. Radioisotopes quantitated included zirconium-95, ruthenium-103, iodine-131, tellurium-132, and barium-140. Other isotopes identified as traces too small to quantitate were molybdenum-99, cerium-141, and neodymium-147.

The highest single gross beta concentration was 91 pCi/m³ observed on a prefilter collected at Rock Springs, Wyo., between January 11 and 12. Analysis of this sample by gamma spectroscopy showed radionuclide concentrations as follows:

Zirconium-95 = 1.0 pCi/m³
Ruthenium-103 = .7 pCi/m³
Iodine-131 = 3.0 pCi/m³
Tellurium-132 = 11.0 pCi/m³
Barium-140 = 4.5 pCi/m³

Of the above radionuclides, only iodine-131 and tellurium-132 were considered to contribute to the hypothetical infant thyroid dose equivalents represented in figure 8. Hypothetical doses

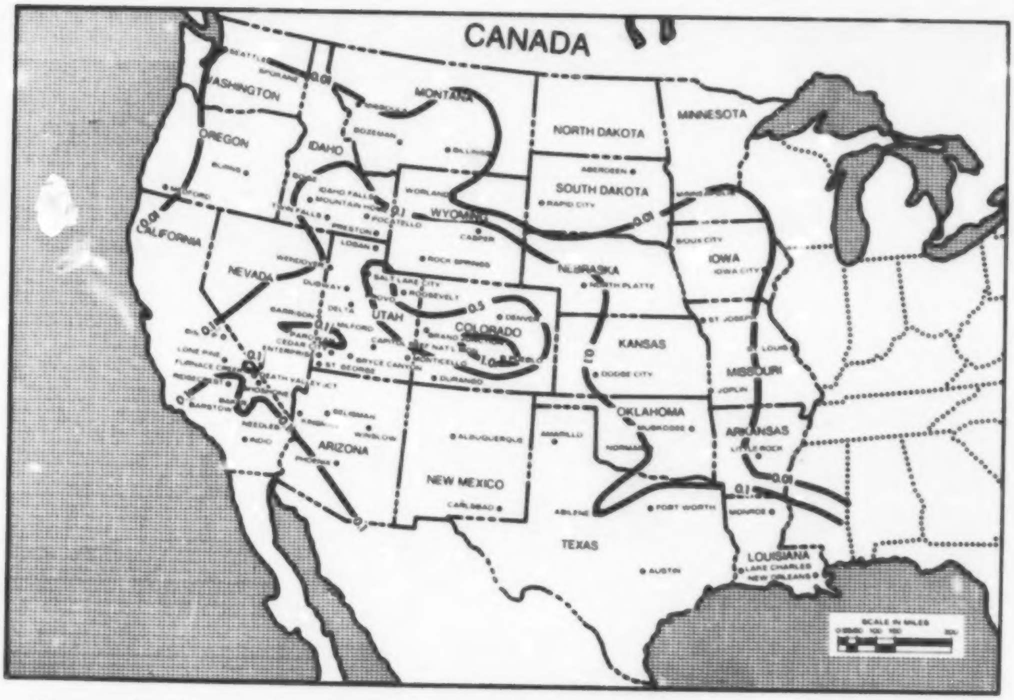
CANADA
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
LOGAN
MONTANA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
CALIFORNIA
NEVADA
WENDOVER
LONE PINE
FURNACE CREEK
RIDGECREST
BARSTOW
NEEDLES
INDIO
DEATH VALLEY JCT
SHOSHONE
UTAH
SALT LAKE CITY
ROOSEVELT
PROVO
DUGWAY
DELTA
GARRISON
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST. GEORGE
BRYCE CANYON
CAPITOL REEF NAT'L MON
MONTICELLO
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
ARIZONA
SELIGMAN
KINGMAN
WINSLOW
PHOENIX
NEW MEXICO
ALBUQUERQUE
CARLSBAD
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
NEBRASKA
NORTH PLATTE
KANSAS
DODGE CITY
OKLAHOMA
MUSKOGEE
NORMAN
TEXAS
AMARILLO
ABILENE
FORT WORTH
AUSTIN
MINNESOTA
IOWA
SIOUX CITY
IOWA CITY
MISSOURI
ST. JOSEPH
ST. LOUIS
JOPLIN
ARKANSAS
LITTLE ROCK
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
0.01
0.1
0.5
1.0
SCALE IN MILES

Figure 8. Hypothetical infant thyroid inhalation dose equivalent (mrem) in the western United States from the Chinese nuclear test of January 1972

from other radionuclides were much smaller than the thyroid dose and were neglected.

In contrast to the previous People's Republic of China test (November 1971), air samples from this test contained no detectable uranium-237.

Hypothetical thyroid inhalation dose equivalents

Hypothetical thyroid dose equivalents corresponding to inhalation of airborne radioactivity were computed using measured time-integrated concentrations of iodine-131 and tellurium-132, and the following dose conversion factors:

Radionuclide	*Dose conversion factor* $\left(\frac{\text{mrem-m}^3}{\mu\text{Ci-s}}\right)$
Iodine-131	0.59
Tellurium-132	.12

These dose conversion factors were derived using the models and standard man assumptions of ICRP Reports 2 and 10 (*5,6*), an assumed thyroid weight for a 1-year-old infant of 2 grams (*7*), and an assumed infant breathing rate of 4.7 m^3/day (*8*). The dose from tellurium-132 was considered to result from uptake of the daughter iodine-132 into the blood stream and subsequently into the thyroid as in ICRP 10. The computations are hypothetical in the sense that the critical receptor (a 1-year-old infant) was assumed to be present and continuously exposed to the airborne radioactivity at each location, whether or not this was actually the case.

Figure 8 shows ASN sampling stations and the isodose pattern for hypothetical infant thyroid dose equivalents in the western United States. All locations identified by name in this figure have ASN stations. The highest calculated infant dose equivalent, approximately 1.2 mrem, occurred at Pueblo, Colo. The hypothetical adult dose equivalent at that location was approximately 0.6 mrem. Adult dose equiv-

85

alents, calculated on the basis of a 20-gram thyroid weight and a breathing rate of 22.8 m^3/day (*8*), were approximately half of the levels shown in figure 8.

Hypothetical infant thyroid dose equivalents from ingestion of radioiodine in milk

Special Pasteurized Milk Network samples were collected at five locations in January 1972. These locations were Salt Lake City, Utah; Denver, Colo; Laramie, Wyo; Austin, Tex, and Las Vegas, Nev. Samples from three of these locations contained measurable amounts of radioiodine. These locations, peak observed iodine-131 concentrations, and the corresponding hypothetical infant thyroid dose equivalents are given in table 1. The dose equivalents were calculated on the basis of a hypothetical 1-year-old infant with a 2-gram thyroid (*7*), an assumed consumption rate of 1 liter/day (*8*) throughout the duration of radioactivity in milk, a dose conversion parameter (14.5 rem per μCi of iodine-131 ingested) derived from ICRP Reports 2 and 10, and the 5-day half-life for iodine-131 in milk recommended by FRC Report 5 (*10*).

The dose equivalents listed in table 1, also assume that the actual peak concentration in milk was that observed at each location. Because only one or two samples were collected at each location, this may not have been the case. FRC Report 5 indicates a time-to-peak for iodine-131 in milk of 2 to 4 days, depending on feeding practices. Assuming deposition occurred on January 12 and 13 when gross beta air concentrations above background were first observed in the region of the above locations, the actual peak concentrations may have been up to twice the values listed. The corresponding dose equivalents would then have been proportionally greater.

Table 1. Peak observed iodine-131 concentrations in milk samples and the corresponding hypothetical infant thyroid dose equivalents

Location	Collection date of sample (1972)	Highest observed iodine-131 concentration (pCi/liter) (9)	Hypothetical infant thyroid dose equivalent (mrem) (to 1 significant figure)
Denver, Colo	Jan 17	70	10
Salt Lake City, Utah	Jan 18	40	5
Laramie, Wyo	Jan 19	80	10

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Press release No. P-21, January 21, 1972.

(*2*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Air surveillance monthly report, January 1972. Western Environmental Research Laboratory, Las Vegas, Nev. 89114 (January 1972).

(*3*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Special thyroid inhalation dose report. Western Environmental Research Laboratory, Las Vegas, Nev. 89114 (January 1972).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation (1959). Health Phys 3:1–380 (1960).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the international commission on radiological protection, ICRP publication 10. A report of Committee IV on evaluation of radiation doses to body tissues from internal contamination due to occupational exposure. Pergamon Press, New York, N.Y. (1968).

(*7*) BRYANT, P. M. Data for assessments concerning controlled and accidental releases of ^{131}I and ^{137}Cs to the atmosphere. Health Phys 17:51–57 (July 1969).

(*8*) U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE. *Radiological Health Handbook.* (January 1970) pp 215–217.

(*9*) WESTERN ENVIRONMENTAL RESEARCH LABORATORY. Pasteurized milk results, monthly report. Western Environmental Research Laboratory, Las Vegas, Nev. 89114 (February 2, 1972).

(*10*) FEDERAL RADIATION COUNCIL. Background ground material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

Data

SECTION I. MILK AND FOOD

Milk Surveillance, October 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

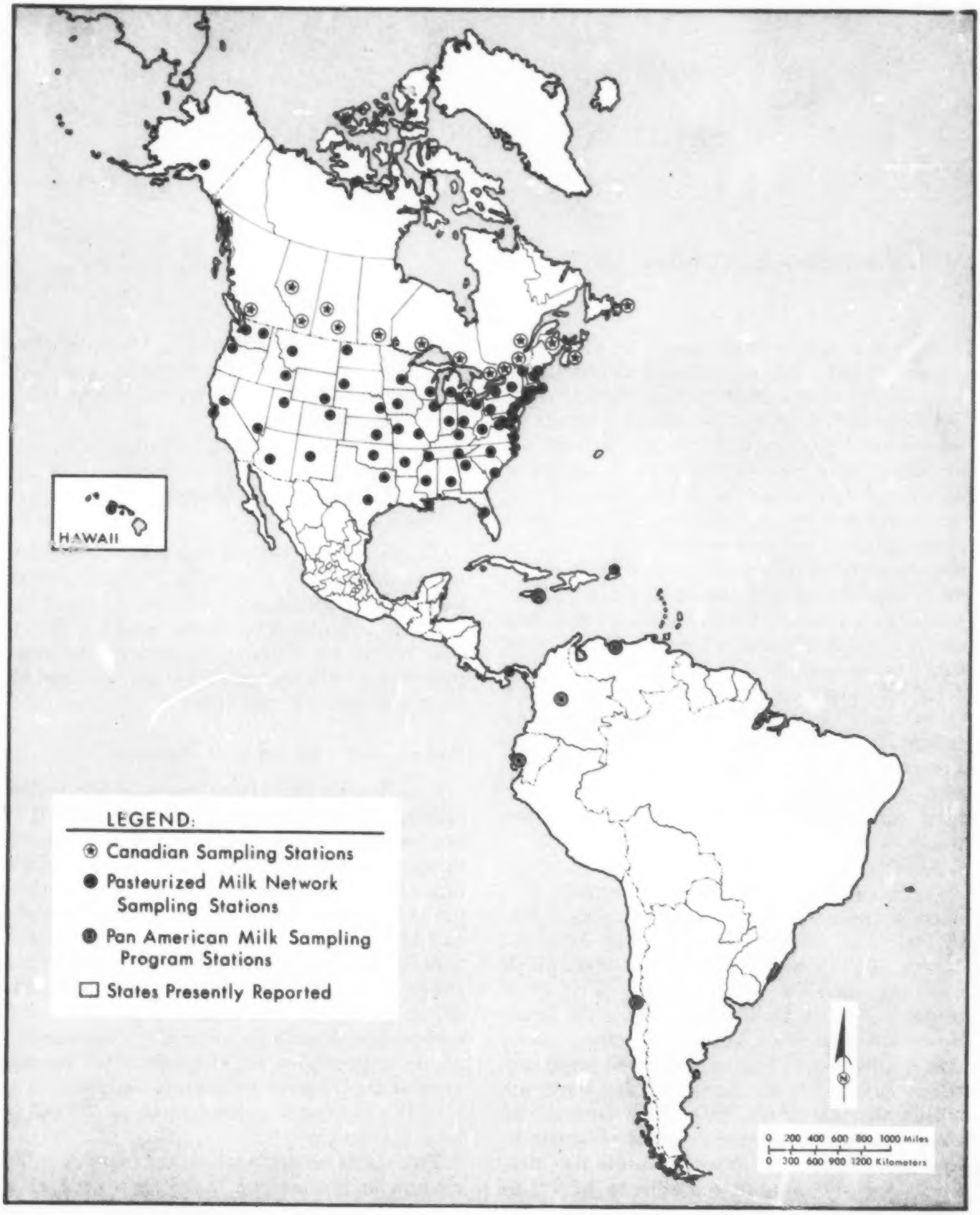
HAWAII
LEGEND:
Canadian Sampling Stations
Pasteurized Milk Network Sampling Stations
Pan American Milk Sampling Program Stations
States Presently Reported
N
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 4 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter;
Strontium-90	1-2 pCi/liter for levels < 20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council (FRC) for specific environmental conditions is presented below. The function of the Council was to provide guidance for the use of Federal agencies in the formulation of radiation standards. The functions of the FRC were transferred to the Environmental Protection Agency in 1970.

Radiation Protection Guides (7,8)

The Radiation Protection Guide (RPG) has been defined by the FRC as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risks to the general public that might result from exposures from routine uses of ionizing radiation and the benefits obtained from the activities causing the exposure.

FRC Reports 1 and 2 (*7,8*) set forth RPG's for specific critical organs (thyroid, bone, bone marrow, and whole body) and intake guidance for strontium-89, strontium-90, and iodine-131. At the same time, the FRC recommended that for radionuclides not specifically considered in the report, Federal agencies should use concentration values which are consistent with recommended RPG's and the general guidance on intake. Therefore, using appropriate FRC recommendations, intake guidance for cesium-137 was considered and is included in this summary.

The basic guide used for cesium-137 is 0.5 rad/year[1] as recommended for the individual in the population or 0.17 rad/year for a suitable sample of the exposed population group. Using the dose relationship for cesium-137 given in FRC Report 7 (*9*) and assuming an equilibrium condition for uptake and excretion of cesium-137 in the body, one obtains the equation:

$$D = (11)\frac{I}{W}1.44T_B$$

where, D = the dose in $\frac{\text{rads}}{\text{year}}$

I = the intake in $\frac{\mu\text{Ci}}{\text{day}}$ of cesium-137

W = the body weight in kilograms,

11 = dose conversion factor based on the absorption of 0.59 MeV per disintegration,

$1.44\ T_b$ = the mean biological life in days, and

T_b = the biological half-life in days.

Where milk is the vector of interest, the infant is the critical individual in the population. The continuous daily intake corresponding to a whole body dose of 0.17 rad/year is calculated to be 3,600 pCi/day, assuming the infant weighs 10 kg and the biological half-life of cesium-137 is 30 days (*9*).

For the purpose of evaluating population exposure, the daily intake of radionuclides by exposed population groups averaged over a year constitutes an appropriate criterion. However, in order to provide guidance to Federal agencies, the FRC described a graded approach involving three ranges of transient rates of daily intake as determined by surveillance, applicable to different degrees of action as follows:

Range I—periodic confirmatory surveillance as necessary;

Range II—quantitative surveillance and routine control;

Range III—evaluation and application of additional control measures as necessary.

Based on the above considerations, table 2 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable.

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk (*10,12*) one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (9,10)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the acci-

---

[1] 0.5 rem/year is given in FRC Report No. 1 (*7*) for whole body dose. In the case of cesium-137, the rem and the rad can be taken as equivalent units.

Table 2. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/year)	Guidance for suitable samples of exposed population group [e]				
			RPG (rad/year)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0–20	20–200	200–2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137 [e]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/year to the bone is estimated to result in a dose of 0.5 rad/year to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

dental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

FRC Reports 5 and 7 (*9,10*) set forth PAG's for the thyroid, bone marrow, and whole body doses from ingestion of foods contaminated with radionuclides following an acute contaminating event. For the case of strontium-89, strontium-90, and cesium-137 contamination, the Council defined three categories of dietary pathways in which action may be required following an acute event as follows:

Category I—transmission of radionuclides to man through the pasture-cow-milk pathway;

Category II—transmission of radionuclides to man through dietary pathways other than the pasture-cow-milk pathway during the first year following an acute contaminating event;

Table 3. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category I (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89 Strontium-90 Cesium-137	bone marrow Bone marrow Whole body	10 in first year; total dose not to exceed 15 [a,b]	3 in first year; total dose not to exceed 5 [a,b]	[c] 1,110,000 [c] 51,000 [c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

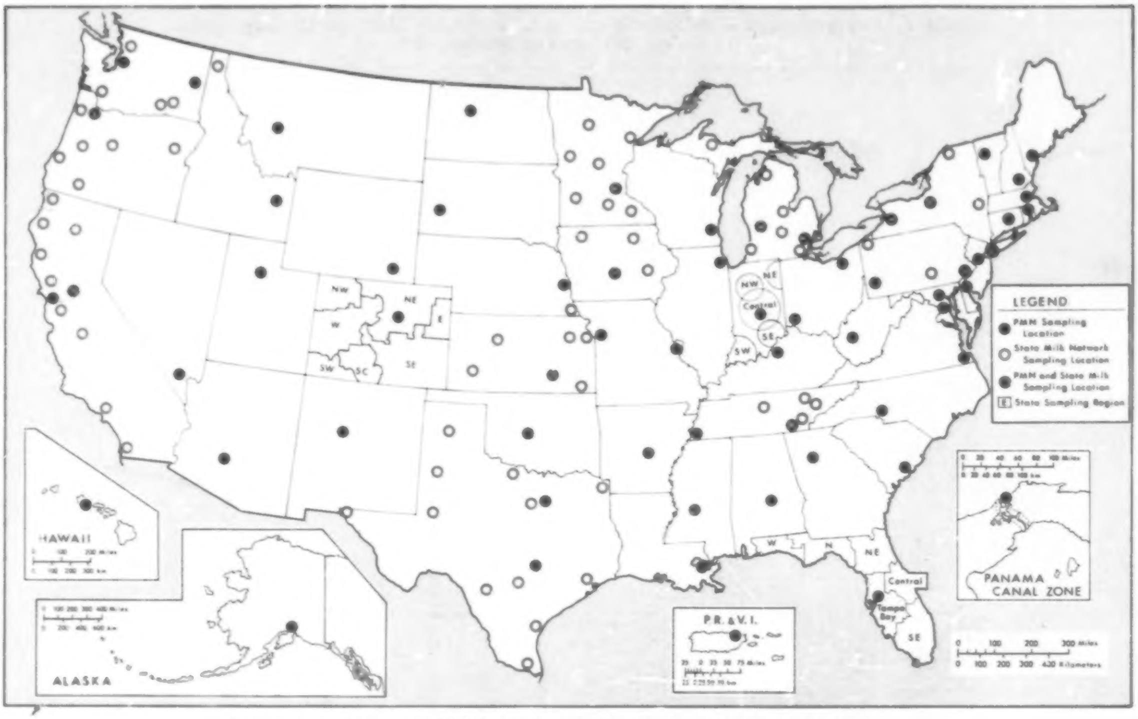

Figure 2. State and PMN milk sampling stations in the United States

Category III—long-term transmission of strontium-90 and cesium-137 through soil into plants in the years following a contaminating event.

This discussion is restricted to a consideration of Category I.

In the case of iodine-131 contamination, the maximum concentration of iodine-131 observed in milk which may occur 2 to 4 days following an acute incident, can be used to project doses for comparison to the PAG for the thyroid. For strontium-89, strontium-90, and cesium-137, the total dose to the critical organ resulting from contributions of all three of these radionuclides must be considered to determine whether the projected dose will exceed the recommended PAG for the organ of interest (bone marrow or whole body).

Based on the above conditions, table 3 represents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. Also given in table 3 are milk concentrations for each of the radionuclides considered, in the absence of the others, which if attained after an acute incident would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for an acute deposition and the pasture-cow-milk-man pathway and from an estimate of the intake prior to reaching the maximum concentration (*10*). Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples.

Data reporting format

Table 4 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports*. The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 4 under each of the reported radionuclides gives the monthly average for the station and the number

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	4	6	14	7
Alaska:	Palmer [c]	P	3	5	0	9
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	11	11	12	6
Calif:	Sacramento [c]	P	0	1	0	0
	San Francisco [c]	P	0	1	0	0
	Del Norte	P	8	11	0	10
	Fresno	P	0	0	0	0
	Humboldt	P	2	4	0	0
	Los Angeles	P	0	5	0	0
	Mendocino	P	0	2	0	0
	Sacramento	P	0	0	0	0
	San Diego	P	0	0	0	0
	Santa Clara	P	0	0	0	0
	Shasta	P	0	2	0	0
	Sonoma	P	0	2	0	0
Colo:	Denver [c]	P	0	4	0	3
	East	R	NA		[d] 0 (2)	0
	Northeast	R	NS		NS	0
	Northwest	R	NS		NS	0
	South Central	R	NS		NS	
	Southeast	R	NS		NS	0
	Southwest	R	NA		[d] 0	0
	West	R	NS		NS	4
Conn:	Hartford [c]	P	4	5	0	7
	Central	P	6	7	0	13
Del:	Wilmington [c]	P	10	9	12	8
D.C:	Washington [c]	P	5 (2)	7	0 (2)	6
Fla:	Tampa [c]	P	5	5	40	38
	Central	R	10	5	11	40
	North	R	6	6	0	17
	Northeast	R	4	5	30	33
	Southeast	R	5	6	26	52
	Tampa Bay area	P	5	5	33	36
	West	R	10	9	15	15
Ga:	Atlanta [c]	P	NS	9	NS	11
Hawaii:	Honolulu [c]	P	0	2	0	1
Idaho:	Idaho Falls [c]	P	4	4	0	0
Ill:	Chicago [c]	P	5	5	0	9
Ind:	Indianapolis [c]	P	6	6	0	2
	Central	P	5	7	10	10
	Northeast	P	4	6	0	10
	Northwest	P	8	8	15	13
	Southeast	P	7	8	0	11
	Southwest	P	5	8	10	12
Iowa:	Des Moines [c]	P	5	4	0	1
	Des Moines	P	7	6	8 (4)	7
	Iowa City	P	9	7	0	8
	Little Cedar	P	7	7	0	11
	Spencer	P	NS	6	NS	10
Kans:	Wichita [c]	P	3	7	0	1
	Coffeyville	P	7	8	9	10
	Dodge City	P	3	5	0	8
	Falls City, Nebr	R	NS	3	NS	8
	Hays	P	5	9	0	8
	Kansas City	P	5	8	0	9
	Topeka	P	7	7	0	8
	Wichita	P	4	8	0	7
Ky:	Louisville [c]	P	6	7	0	6
La:	New Orleans [c]	P	10	12	0	5
Maine:	Portland [c]	P	7	6	29	20
Md:	Baltimore [c]	P	7	7	26	6
Mass:	Boston [c]	P	5	7	20	12
Mich:	Detroit [c]	P	6	6	0	8
	Grand Rapids [c]	P	10	8	0	7
	Bay City	P	5	5	NA	10
	Charlevoix	P	0	7	NA	11
	Detroit	P	5	4	NA	9
	Grand Rapids	P	0	5	NA	7
	Lansing	P	0	5	NA	10
	Marquette	P	4	5	NA	21
	Monroe	P	0	2	NA	4
	South Haven	P	3	5	NA	8
Minn:	Minneapolis [c]	P	6	7	0	16
	Bemidji	P	7	7	16	18
	Duluth	P	18	15	17	27
	Fergus Falls	P	7	8	11	15
	Little Falls	P	12	18	16	40
	Mankato	P	5	5	0	11
	Marshall	P	11	11	0	14

See footnotes at end of table.

94

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Minneapolis	P	8	7	0	14
	Rochester	P	5	6	11	11
Miss:	Jackson [c]	P	7	9	15	7
Mo:	Kansas City [c]	P	3	5	0	3
	St. Louis [c]	P	3	6	0	3
Mont:	Helena [c]	P	3	4	0	4
Nebr:	Omaha [c]	P	4	6	0	1
Nev:	Las Vegas [c]	P	0	1	0	0
N.H:	Manchester [c]	P	7	8	11	17
N.J:	Trenton [c]	P	7	7	0	5
N. Mex:	Albuquerque [c]	P	0	1	0	0
N.Y:	Buffalo [c]	P	6	6	0	5
	New York City [c]	P	8	8	11	9
	Syracuse	P	5	6	12	7
	Albany	P	4	6	0 (6)	0
	Buffalo	P	NS		0	0
	Massena	P	NS		0	0
	New York City	P	7	7	0	0
	Syracuse	P	NS		0	0
N.C:	Charlotte [c]	P	8	9	0	8
N. Dak:	Minot [c]	P	7	9	0	9
Ohio:	Cincinnati [c]	P	5	6	0	3
	Cleveland [c]	P	8	7	0	7
Okla:	Oklahoma City [c]	P	2	5	0	5
Oreg:	Portland [c]	P	3	4	0	3
	Baker	P	5	3	[d] 0	2
	Coos Bay	P	6	4	24	5
	Eugene	P	2	1	[d] 0	1
	Medford	P	2	1	38	9
	Portland composite	P	NS	4	NS	6
	Portland local	P	NS	7	NS	7
	Redmond	P	3	2	[d] 0	2
	Tillamook	P	7	6	22	12
Pa:	Philadelphia [c]	P	6	6	0	3
	Pittsburgh [c]	P	7	9	15	6
	Dauphin	P	3	7	11	12
	Erie	P	6	7	0	12
	Philadelphia	P	3	5	11	8
	Pittsburgh	P	7	7	11	13
R.I:	Providence [c]	P	5	6	0	11
S.C:	Charleston [c]	P	8	8	15	14
S. Dak:	Rapid City [c]	P	4	7	0	3
Tenn:	Chattanooga [c]	P	7	8	11	8
	Memphis [c]	P	8	7	0	2
	Chattanooga	P	NA	10	0	12
	Clinton	R	NA	10	0	15
	Fayetteville	R	NA	10	11	7
	Kingston	R	NA	9	0	7
	Knoxville	P	NA	8	0	8
	Lawrenceburg	R	NA	8	0	9
	Nashville	P	NA	8	0	6
	Pulaski	R	NA	7	0	6
	Sequoyah	R	2	7	6	20
Tex:	Austin [c]	P	0	2	0	0
	Dallas [c]	P	5	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	3	3	0	3
Vt:	Burlington [c]	P	6	6	13	9
Va:	Norfolk [c]	P	5	6	11	7
Wash:	Seattle [c]	P	0	3	0	3
	Spokane [c]	P	3	4	0	7
	Benton County	R	NS	1	NS	0
	Franklin County	R	0	1	0	0
	Longview	R	3	3	0	0
	Sandpoint, Idaho	R	4	9	11	14
	Skagit County	R	4	7	0	5
W. Va:	Charleston [c]	P	4	8	0	5
Wisc:	Milwaukee [c]	P	5	5	0	6
Wyo:	Laramie [c]	P	0	3	0	2

See footnotes at end of table.

95

Table 4. Concentrations of radionuclides in milk for October 1972 and 12-month period, November 1971 through October 1972—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		0	18
Edmonton	P	NA		15	24
British Columbia:					
Vancouver	P	NA		13	21
Manitoba:					
Winnipeg	P	NA		11	19
New Brunswick:					
Fredericton	P	NA		NA	NA
Newfoundland:					
St. John's	P	NA		19	25
Nova Scotia:					
Halifax	P	NA		13	18
Ontario: Ottawa	P	NA		0	10
Sault Ste. Marie	P	NA		15	25
Thunder Bay	P	NA		12	20
Toronto	P	NA		0	9
Windsor	P	NA		0	8
Quebec: Montreal	P	NA		0	13
Quebec	P	NA		10	23
Saskatchewan:					
Regina	P	NA		0	15
Saskatoon	P	NA		0	14
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal [c]	P	0	1	0	10
Chile: Santiago	P	3	1	0	0
Colombia: Bogota	P	0	1	0	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Mandeville	P	5	3	32	50
Puerto Rico:					
San Juan [c]	P	0	1	0	4
Venezuela:					
Caracas	P	0	0	0	0
PMN network average [e]		5	6	4	6

[a] P, pasteurized milk.
R, raw milk

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter
Oregon—15 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 4, surveillance results are given for strontium-90 and cesium-137 for October 1972 and the 12-month period, November 1971 to October 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 4 since levels at the great majority of the stations for October 1972 were below the respective practical reporting levels. Table 5 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 18 pCi/liter in the United States for October 1972, and the highest 12-month average was 18 pCi/liter (Little Falls, Minn.) representing 9.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 40 pCi/liter in the United States for October 1972, and the highest 12-month average was 52 pCi/liter (Southeast Florida) representing 1.4 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida *(11)* and Jamaica.

Table 5. Strontium-89, iodine-131, and barium-140 in milk, October 1972

Sampling location	Concentration (pCi/liter)		
	Strontium-89	Barium-140	Iodine-131
Colo: East (State)		36	
N.Y: New York City (State)	7		
Oreg: Medford (State)		13	23

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730-746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium-89 and strontium-90 measurements in milk, July 1971, Technical experiment 71-MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1971).

(6) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475-488 (September 1968).

(7) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(8) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(9) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89 strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(11) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, April-June 1972

National Environmental Research Center—Las Vegas, Environmental Protection Agency

The Milk Surveillance Network, operated by the National Environmental Research Center—Las Vegas (NERC-LV)[1] consists of about 30 sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

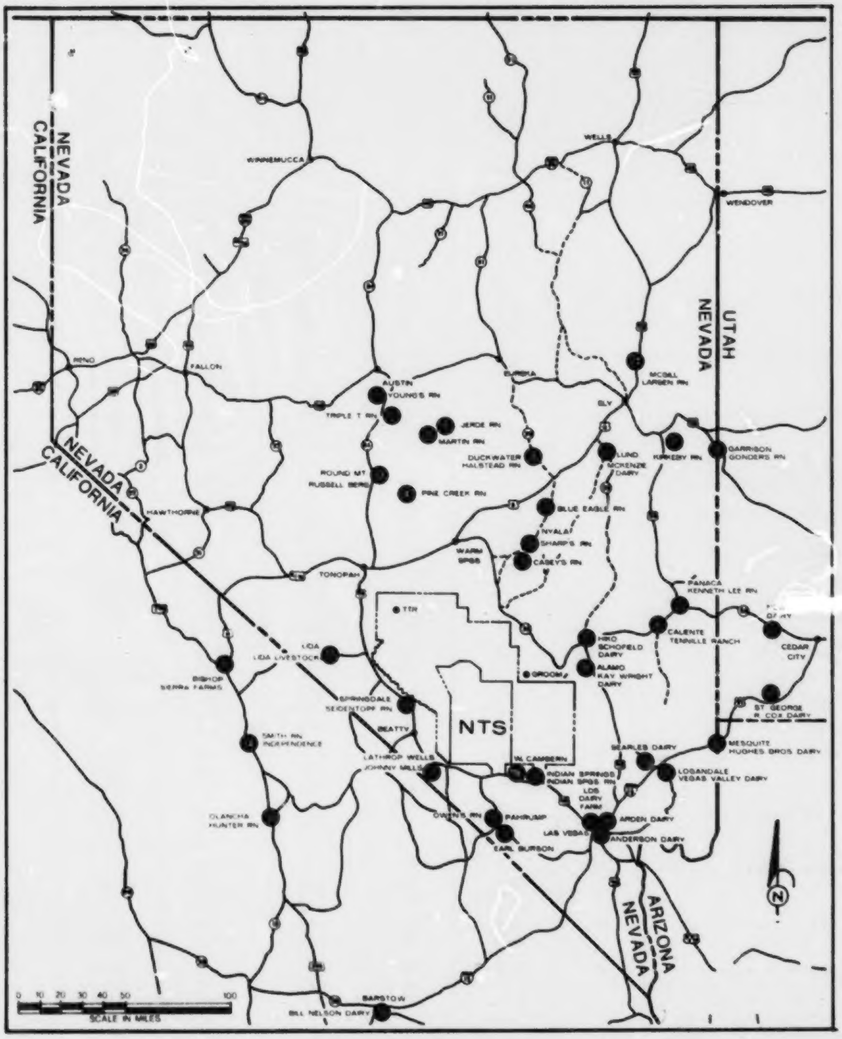
WINNEMUCCA
WELLS
WENDOVER
NEVADA
CALIFORNIA
UTAH
NEVADA
RENO
FALLON
AUSTIN
YOUNG'S RN
TRIPLE T RN
JERDE RN
MARTIN RN
EUREKA
MCGILL
LARSEN RN
ELY
DUCKWATER
HALSTEAD RN
LUND
MCKENZIE
DAIRY
KIRKEBY RN
GARRISON
GONDERS RN
ROUND MT
RUSSELL BERG
PINE CREEK RN
BLUE EAGLE RN
HAWTHORNE
NYALA
SHARP'S RN
WARM
SPGS
CASEY'S RN
TONOPAH
PANACA
KENNETH LEE RN
TTR
CALIENTE
TENNILLE RANCH
CEDAR
CITY
LIDA
LIDA LIVESTOCK
BISHOP
SERRA FARMS
HIKO
SCHOFELD
DAIRY
ALAMO
KAY WRIGHT
DAIRY
GROOM
SPRINGDALE
SEIDENTOPF RN
ST GEORGE
R COX DAIRY
BEATTY
NTS
SMITH RN
INDEPENDENCE
MESQUITE
HUGHES BROS DAIRY
SEARLES DAIRY
LATHROP WELLS
JOHNNY MILLS
W. CAMBERN
INDIAN SPRINGS
INDIAN SPGS RN
LOGANDALE
VEGAS VALLEY DAIRY
LOS
DAIRY
FARM
OLANCHA
HUNTER RN
OWEN'S RN
PAHRUMP
ARDEN DAIRY
LAS VEGAS
ANDERSON DAIRY
EARL BURSON
ARIZONA
NEVADA
N
0 10 20 30 40 50 100
SCALE IN MILES
BARSTOW
BILL NELSON DAIRY

Figure 1. NERC-LV milk surveillance network

---

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

Table 1. Milk surveillance results, April-June 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	4/5	11	<10	<2	3 ±2	NA
		5/9	11	<10	<2	3 ±2	NA
		6/2	11	<10	2 ±2	2 ±2	NA
Hinkley:							
Bill Nelson Dairy	13	4/3	12	<10	<1	<1	NA
		5/8	12	<10	<2	<1	NA
		6/1	12	<10	2 ±2	<1	NA
Independence:							
Smith Ranch	14	4/5	13	<10	<2	2 ±1	NA
		5/9	13	<10	<2	3 ±2	NA
		6/2	13	[c] <100	2 ±2	<1	NA
Olancha:							
Hunter Ranch	30	4/5	13	<10	<3	3 ±2	NA
		5/8	13	<10	<2	<1	NA
		6/1	13	<10	<2	3 ±2	NA
Nevada:							
Alamo:							
Williams Dairy	1	4/4	12	<10	<2	2 ±1	NA
		5/5	12	<10	<2	2 ±1	NA
		6/2	12	<10	<2	<1	NA
Austin:							
Triple T Ranch	2	4/4	13	<10	<2	<1	850 ±220
		5/3	13	<10	<2	<1	500 ±220
Caliente:							
Tennille Ranch	6	5/4	13	<10	<2	3 ±1	NA
		6/1	13	<10	4 ±2	<2	NA
Currant:							
Blue Eagle Ranch	7	4/7	13	50	<2	3 ±2	NA
		5/5	13	50	<3	6 ±2	NA
		6/2	13	100	<3	6 ±2	NA
Duckwater:							
Halstead Ranch	8	4/6	13	10	<2	7 ±2	NA
		5/5	13	<10	2 ±2	2 ±2	NA
		6/1	13	<10	<2	4 ±2	NA
Eureka:							
Martin Ranch	10	4/9	13	30	4 ±3	9 ±2	NA
		5/2	13	10	5 ±4	11 ±3	NA
		6/14	13	<10	7 ±5	9 ±3	NA
Hiko:							
Schofield Dairy	12	4/4	12	<10	<2	5 ±2	230 ±190
		5/2	12	<10	<2	2 ±1	<220
		6/2	12	<10	<2	<1	380 ±210
Indian Springs:							
Cambern Ranch (A)	16	4/12	13	<10	<1	<1	NA
Indian Springs Ranch	15	5/5	13	<10	1 ±1	<1	NA
Las Vegas:							
Anderson Dairy	17	4/11	11	<10	<2	2 ±1	NA
		5/9	11	<10	<2	2 ±1	NA
		6/1	11	<10	<2	1 ±1	NA
Arden Dairy	18	4/11	11	<10	<2	3 ±1	NA
		5/9	11	<10	<2	2 ±1	NA
		6/1	11	<10	2 ±2	<1	NA
LDS Dairy Farms	19	4/12	12	<10	<2	<1	<200
		5/9	12	<10	<2	2 ±1	<220
		6/1	12	<10	<2	<1	<210
Lathrop Wells:							
Mills Ranch	20	4/11	13	<10	<2	<1	NA
		5/4	13	[c] <100	<2	2 ±1	NA
Logandale:							
Vegas Valley Dairy	22	4/4	12	<10	<2	<1	NA
		5/4	12	<10	1 ±1	<1	NA
		6/1	12	<10	<2	<1	NA
Lund:							
McKenzie Dairy	23	4/5	12	<10	<2	4 ±1	<190
		5/4	12	<10	<2	2 ±2	210 ±210
		6/2	12	<10	<3	6 ±2	300 ±210
McGill:							
Larsen Ranch	24	4/4	13	<10	<2	2 ±1	NA
		5/3	13	<10	2 ±2	<1	NA
		6/1	13	<10	<2	2 ±1	NA
Mesquite:							
Hughes Bros Dairy	25	4/4	12	<10	<2	<1	200 ±190
		5/4	12	<10	2 ±2	<1	<220
		6/1	12	<10	1 ±1	<1	410 ±220
Moapa:							
Searles Dairy	26	4/4	12	<10	<2	2 ±1	NA
		6/20	12	<10	<2	2 ±2	NA
Nyala:							
Sharp's Ranch	28	4/5	13	<10	<2	3 ±1	<220
		5/3	13	<10	<2	2 ±1	<220
		6/1	13	<10	<2	4 ±2	<200

See footnotes at end of table.

100

Table 1. Milk surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Pahrump:							
Owens Ranch	31	4/11	13	<10	<1	<1	NA
		5/4	13	<10	<2	<1	NA
		6/2	13	<10	<2	<1	NA
Panaca:							
Kenneth Lee Ranch	33	4/5	13	10	<2	4 ±2	NA
		5/3	13	<10	<2	4 ±1	NA
		6/1	13	<10	<2	3 ±2	NA
Round Mt:							
Russell Berg	34	4/4	13	20	<3	7 ±2	NA
		6/1	13	10	<2	6 ±2	NA
Shoshone:							
Kirkeby Ranch	35	4/4	13	10	<2	6 ±2	NA
		5/8	13	<10	<2	4 ±2	NA
		6/1	13	<10	3 ±3	6 ±2	NA
Springdale:							
McCurdy Ranch	36	4/12	13	<10	<2	2 ±1	NA
Seidentopf Ranch	36	5/4	13	[c] <100	3 ±2	<1	NA
		6/2	13	<10	2 ±2	<1	NA
Utah:							
Garrison:							
Gonders Ranch	11	4/4	13	<10	<2	2 ±1	NA
		5/8	13	<10	<2	2 ±1	NA
		6/1	13	<10	2 ±2	2 ±1	NA
Newcastle:							
Newcastle Dairy	27	4/6	12	10	<2	3 ±1	NA
		5/3	12	<10	<2	2 ±1	NA
St. George:							
R. Cox Dairy	37	4/5	12	20	<2	3 ±1	NA
		5/4	12	<10	<2	<1	NA
		6/2	12	<10	2 ±2	<1	NA

[a] 11, pasteurized milk.
12, raw milk from Grade A producer(s).
13, raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size.
A, alternate milk sampling station.
NA, not analyzed.

area is conducted to determine radionuclide concentrations and to take protective action, if required. Other sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in April, May, and June 1972 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (10 pCi/liter), no gamma-emitting fission products were detected in any of the samples by gamma spectroscopic analysis. Levels of tritium, strontium-89, and strontium-90 near the MDA's for these radionuclides (approximately 200 pCi/liter, 2 pCi/liter, and 1 pCi/liter, respectively) were also measured by radiochemistry analyses.

Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon-14 in Total Diet and Milk	July-December 1971	May 1972
Connecticut Standard Diet	January-December 1971	December 1972
This network has been discontinued.		
Institutional Total Diet	October-December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium-90 in Tri-City Diets	January-December 1971	December 1972

102

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Michigan	January-June 1970	November 1971
Minnesota Municipal Water	July 1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968-1970	September 1972
Radiostrontium in Tap Water	July-December 1971	November 1972
Tritium Surveillance System	April-June 1972	January 1973
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs	January-March 1972	December 1972

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Kansas Surface Waters January-December 1971

Radiation Control Section
Kansas State Department of Health

Monitoring of levels of radioactivity in the surface waters of Kansas is analyzed by the Kansas State Department of Health, Radiation Control Section, in cooperation with the Kansas Water Quality Control Section and the U.S. Geological Survey. This surveillance program is important because of both the present and future potential use of Kansas surface waters for domestic, recreational, and industrial purposes.

Liter samples are collected every month at each location shown in figure 1. These samples are analyzed for gross alpha and beta radioactivity. In order to establish baseline data in anticipation of the two power reactors which will be located on the Missouri River in Nebraska, each Missouri River sample is gamma scanned for specific radionuclides. Specific radionuclide analyses are also performed on any other samples which indicate high gross alpha-beta activity. Radioactivity in these waters consists of the natural radioactivity picked up by flowing streams, radioactivity from sewage discharge into the streams, and some contribution by industrial waste. The final contributing factor to radioactivity content is fallout, particularly over large expanses of open water, such as reservoirs and lakes.

Analytical procedures

Radioactivity analyses are performed by the Kansas Radiation Laboratory. Measurements of gross alpha-plus-beta radioactivity are made with a windowless gas-flow proportional counter. Each sample is evaporated in an aluminum planchet, dried at 250°C, and then counted. Specific radionuclide analyses are determined by gamma spectroscopy or chemical separation.

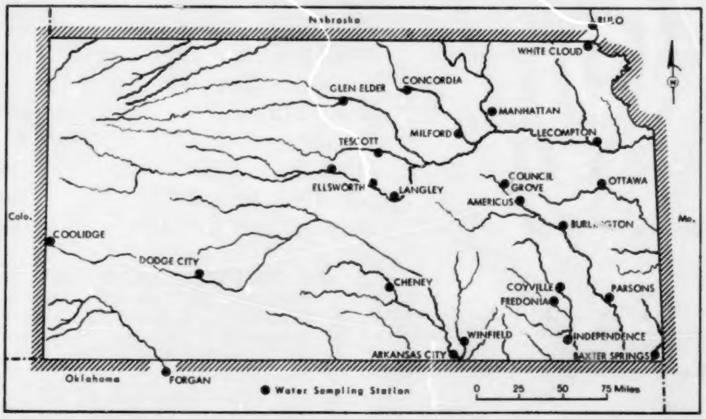
Nebraska
RULO
WHITE CLOUD
CONCORDIA
GLEN ELDER
MANHATTAN
MILFORD
LECOMPTON
TESCOTT
ELLSWORTH
LANGLEY
COUNCIL GROVE
OTTAWA
AMERICUS
Colo.
BURLINGTON
Mo.
COOLIDGE
DODGE CITY
CHENEY
COYVILLE
FREDONIA
PARSONS
WINFIELD
INDEPENDENCE
ARKANSAS CITY
BAXTER SPRINGS
Oklahoma
FORGAN
● Water Sampling Station
0 25 50 75 Miles
N

Figure 1. Kansas surface water sampling stations

Table 1. Gross radioactivity in Kansas surface waters, January-June 1971

Rivers	Sampling stations	Radioactivity concentration (pCi/liter)											
		January		February		March		April		May		June	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas	Arkansas City	3	16	22	0	3	2	10	0	0	0	3	3
	Dodge City	55	0	61	32	56	0	31	0	20	9	24	[a]21
	Coolidge	55	21	41	0	49	8	16	17	66	0	39	18
Big Blue	Manhattan	3	14	NS	NS	2	11	3	10	4	30	3	11
Fall	Fredonia	0	12	1	16	3	12	2	0	0	7	4	14
Kansas	Lecompton	4	13	3	21	3	0	4	13	2	5	6	1
Marais Des Cygnes	Ottawa	NS	NS	2	8	4	0	1	18	1	7	3	6
Missouri	Rulo, Nebr.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	White Cloud	6	0	12	14	8	0	9	5	11	23	9	26
Neosho	Americus	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Burlington	6	7	NS	NS	2	11	5	4	NS	NS	4	1
	Council Grove	NS	NS	4	14	0	6	5	3	4	0	NS	NS
	Parsons	3	2	1	0	3	7	5	6	2	2	0	6
Ninnescah	Cheney Reservoir	1	4	1	7	1	9	9	6	2	0	8	3
	Peck	2	4	0	0	2	2	8	0	0	13	4	17
Republican	Concordia	NS	NS	5	11	8	3	7	25	1[illegible]	9	5	17
	Milford	4	18	11	10	7	5	7	18	4	31	6	24
Saline	Tescott	3	6	2	14	0	0	8	4	13	0	11	13
Smoky Hill	Ellsworth	13	23	6	0	0	0	14	60	9	20	3	19
	Langley	6	14	4	3	3	0	5	19	8	9	5	9
Solomon	Glen Elder	7	[a]40	3	[a]42	6	28	9	16	10	16	2	37
Spring	Baxter Springs	1	0	0	2	1	1	0	1	NS	NS	2	7
Verdigris	Coyville	1	8	0	7	0	4	2	8	5	2	1	8
	Independence	0	0	4	2	3	0	1	8	4	4	2	0
Walnut	Winfield	4	0	0	5	12	2	6	0	4	2	NS	NS

Table 1. Gross radioactivity in Kansas surface waters, July-December 1971—continued

Rivers	Sampling stations	Radioactivity concentration (pCi/liter)											
		July		August		September		October		November		December	
		Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
Arkansas	Arkansas City	8	3	1	0	0	9	NS	NS	7	11	11	9
	Dodge City	32	7	48	12	28	13	25	16	1	34	21	42
	Coolidge	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Big Blue	Manhattan	3	11	0	20	2	0	0	18	0	6	1	1
Fall	Fredonia	4	15	0	9	2	0	2	0	0	6	1	1
Kansas	Lecompton	0	0	0	60	NS	NS	2	0	1	7	1	0
Marais Des Cygnes	Ottawa	2	7	0	18	0	0	1	22	1	0	8	16
Missouri	Rulo, Nebr	7	0	9	7	8	13	8	0	13	13	10	16
	White Cloud	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Neosho	Americus	NS	NS	NS	NS	NS	NS					NS	NS
	Burlington	4	11	3	12	1	1	2	20	3	12	NS	NS
	Council Grove	4	1	NS	NS	NS	NS	NS	NS	NS	NS	4	22
	Parsons	1	12	0	6	3	0	1	0	4	11	NS	NS
Ninnescah	Cheney Reservoir	7	0	0	20	3	32	5	27	5	30	1	1
	Peck	4	11	1	0	0	0	1	0	2	19	7	9
Republican	Concordia	9	22	2	9	10	4	2	12	7	4	4	13
	Milford	4	8	5	14	4	6	10	0	0	2	NS	NS
Saline	Tescott	0	27	9	0	13	12	14	0	2	34	12	38
Smoky Hill	Ellsworth	3	0	4	17	0	0	10	3	8	0	10	37
	Langley	0	15	0	7	5	6	1	24	15	3	5	19
Solomon	Glenn Elder	NS	NS	NS	NS	6	24	9	24	7	23	5	5
Spring	Baxter Springs	NS	NS	1	0	1	0	1	0	3	13	4	5
Verdigris	Coyville	6	10	3	17	3	6	0	0	1	8	0	11
	Independence	1	8	2	18	0	0	0	6	1	9	0	19
Walnut	Winfield	5	15	0	0	5	5	1	0	2	0	2	31

[a] Gamma scan performed, but activity not sufficient to permit identification of specific radionuclides.
NS, no sample.

Discussion

Table 1 shows the gross alpha and gross alpha-plus-beta radioactivity in the total solids in Kansas surface waters from January through December 1971. These waters are used for domestic, industrial, and recreational purposes. The Arkansas River samples have consistently high activity which is attributed to uranium picked up from its drainage in Colorado.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	December 1971

Tritium Surveillance System, July-September 1972

Office of Radiation Programs
Environmental Protection Agency

The Tritium Surveillance System is an expansion of previous tritium surveillance activities conducted by the Office of Radiation Programs, Environmental Protection Agency (EPA). The principal effort in the past by the Office of Radiation Programs related to tritium releases has been the Tritium in Surface Water Network. This network was established in 1964 to measure and monitor tritium concentrations in major river systems in the United States and to provide surveillance at surface water stations downstream from selected nuclear facilities. The network consisted of selected stations from existing water pollution sampling stations operated by the Office of Water Programs of EPA. The final data from this network for January-June 1970, have been published previously (*1*).

Another effort of the Office of Radiation Programs was a tritium in precipitation program. This project was established in 1967 at selected Radiation Alert Network (RAN) stations covering the United States, including Alaska and Hawaii. The RAN is operated by the Office of Air Programs of EPA. The data from this project for July-December 1969 have been published previously (*2*). Due to the increased interest in tritium releases from nuclear facilities and the potential long-term accumulation in the environment, a national system was established to incorporate these projects or networks into one overall system.

Present network

The Tritium Surveillance System consists of 70 drinking water samples collected quarterly at the RAN stations, precipitation samples collected daily and analyzed monthly from 8 of the RAN stations (figure 1), and surface samples collected quarterly at 39 surface water

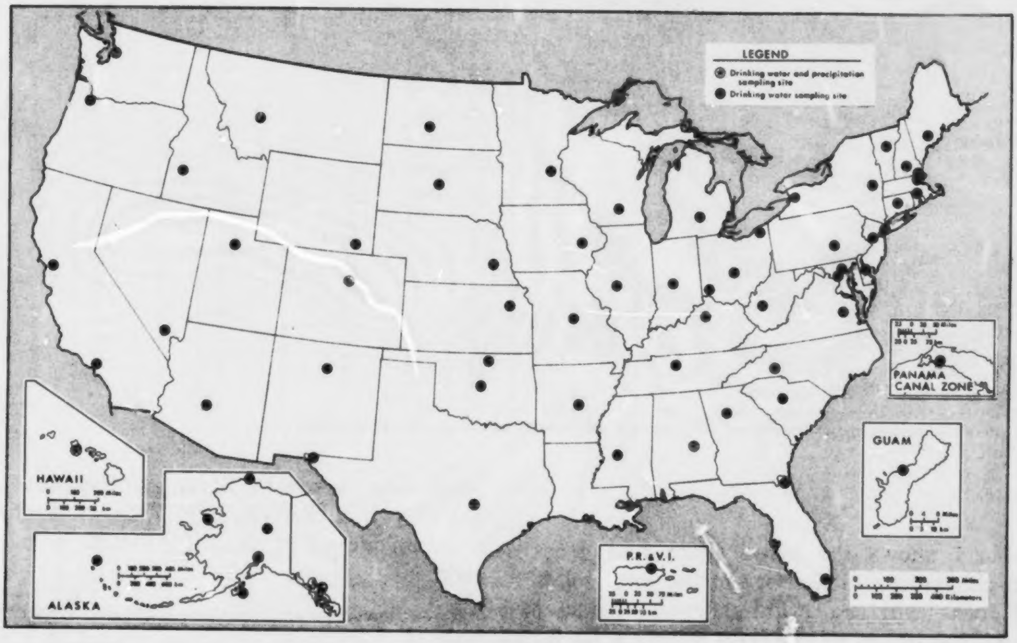
LEGEND
● Drinking water and precipitation sampling site
● Drinking water sampling site
HAWAII
ALASKA
P.R. & V.I.
GUAM
PANAMA CANAL ZONE

Figure 1. Drinking water and precipitation sampling locations for tritium surveillance system

sampling systems stations (figure 2). The specific locations for the surface were determined by examining the water drainage areas to assure that a representative sample from a large area or region was obtained, and if possible, incorporating several nuclear facility sites. All nuclear facilities that were operating, being constructed, or planned through 1975 were considered. Consideration was also given to the current surveillance programs of the States that will be involved in the collection of the samples. The surface water samples are collected quarterly either downstream from a nuclear facility or at a background station.

The tap water samples are collected by the RAN operators on a quarterly basis. The precipitation samples are also collected by the RAN operators on a daily basis.

All samples are sent to either the Eastern Environmental Radiation Laboratory or the National Environmental Research Center—Las Vegas, for analysis. Analytical values which are not statistically significant at the 2-sigma confidence level have been reported as zero.

Results and discussion

Table 1 presents the tritium concentrations in drinking water at the RAN stations for July-September 1972. The average tritium concentration was 0.3 nCi/liter.

Table 1. Tritium concentration in tap water (RAN stations, July-September 1972

Location		Date collected (1972)	Tritium concentration [a] (nCi/liter ± 2 σ)[b]
Ala:	Montgomery	7/12	0
Alaska:	Anchorage	7/5	.6
	Attu Island	NS	
	Fairbanks	NS	
	Juneau	7/11	.3
	Kodiak	7/5	0
	Nome	7/8	.6
	Point Barrow	7/5	.7
Ariz:	Phoenix	7/5	0
Ark:	Little Rock	7/8	.7
Calif:	Berkeley	7/5	.5
	Los Angeles	7/7	0
C.Z:	Ancon	7/21	0
Colo:	Denver	7/6	.9
Conn:	Hartford	7/3	0
Del:	Dover	7/5	0
D.C:	Washington	7/12	0
Fla:	Jacksonville	7/3	0
	Miami	7/5	0
Ga:	Atlanta	7/5	.2
Guam:	Agana	7/8	0
Hawaii:	Honolulu	7/3	.7
Idaho:	Boise	7/8	.3
Ill:	Springfield	7/8	.3
Ind:	Indianapolis	7/5	0
Iowa:	Iowa City	7/8	.6
Kans:	Topeka	7/6	0
Ky:	Frankfort	7/26	.8
La:	New Orleans	7/7	.4
Maine:	Augusta	7/12	.3
Md:	Baltimore	7/8	0
Mass:	Lawrence	7/5	.3
	Winchester	7/8	.4
Mich:	Lansing	7/11	0
Minn:	Minneapolis	7/6	.6
Miss:	Jackson	7/5	0
Mo:	Jefferson City	7/18	0
Mont:	Helena	7/10	.4
Nebr:	Lincoln	7/6	0
Nev:	Las Vegas	7/5	1.6
N.H:	Concord	7/5	.3
N.J:	Trenton	7/5	.2
N. Mex:	Sante Fe	7/10	.3
N.Y:	Albany	7/5	.2
	Buffalo	7/7	.4
	New York City	7/8	0
N.C:	Gastonia	7/5	.2
N. Dak:	Bismarck	7/7	.9
Ohio:	Cincinnati	7/5	.3
	Columbus	7/14	.2
	Painesville	7/5	.4
Okla:	Oklahoma City	7/8	.8
	Ponca City	7/5	.5
Oreg:	Portland	7/8	.4
Pa:	Harrisburg	7/7	.3
P.R:	San Juan	7/5	0
R.I:	Providence	7/7	.2
S.C:	Columbia	7/5	0
S. Dak:	Pierre	7/5	1.0
Tenn:	Nashville	7/3	.2
Tex:	Austin	7/8	0
	El Paso	7/5	1.0
Utah:	Salt Lake City	7/5	.9
Vt:	Barre	7/5	.2
Va:	Richmond	7/7	.3
Wash:	Seattle	7/6	.3
	Spokane	7/3	.8
W. Va:	Charleston	7/5	.2
Wisc:	Madison	7/7	0
Wyo:	Cheyenne	7/5	1.0
Average			0.3

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

Previous articles on the Tritium Surveillance System have reported dose equivalents from tritium in body water based on a relationship derived by Moghissi and Porter (*3*). Their relationship assumed a quality factor of 1.7 for tritium beta rays based on a 1966 ICRP recommendation (*4*). Recently the NCRP has recommended a quality factor of 1 for tritium beta rays (*5*) and this recommendation has been adopted for this and subsequent reports. Following the notation adopted by the ICRU (*6*) substitution of a quality factor of 1 in Moghissi and Porter calculations yields:

$$H\ (\text{mrem/year} = 0.1C\ (\text{nCi/liter})$$

Where H is the dose equivalent rate and C represents the tritium concentration in body water.

Assuming that the concentration of tritium in all water taken into the body is equal to that found in the drinking water and also that the specific activity of tritium in the body is essentially the same as that in the drinking water, then the radiation dose may be estimated.

Table 2. Tritium concentration in surface water, July-September 1972

Location		Water source	Facility	Collection date (1972)	Concentration [a] (nCi/liter ± 2σ)[b]
Ala:	Decatur	Tennessee River	Browns Ferry	7/31	0.4
Ark:	Morrilton	Arkansas River	Arkansas Nuclear	7/5	.4
Calif:	Eureka	Humboldt Bay	Humboldt Bay	8/25	0
	San Onofre	Pacific Ocean	San Onofre	7/19	.4
Colo:	Greely	South Platte River	Fort St. Vrain	7/6	1.1
Conn:	East Haddam	Connecticut River	Connecticut Yankee & Vermont Yankee	7/18	.7
	Waterford	Long Island Sound	Millstone	7/18	0
Fla:	Crystal River	Gulf of Mexico	Crystal River	7/6	0
	Homestead	Biscayne Bay	Turkey Point	8/30	0
Idaho:	Buhl	Snake River	National Reactor Testing Station	7/3	.3
Ill:	Moline	Mississippi River	Quad-Cities	7/11	.4
	Morris	Illinois River	Dresden and Argonne	7/12	.3
La:	New Orleans	Mississippi River	(Several)	7/5	.7
Md:	Conowingo	Susquehanna River	Peach Bottom and Three Mile Island	7/6	.4
	Lusby	Chesapeake Bay	Calvert Cliffs	7/6	.2
Mass:	Rowe	Deerfield River	Yankee	7/18	2.3
Mich:	Charlevoix	Lake Michigan	Big Rock Point	7/21	.2
	Monroe	Lake Erie	Enrico Fermi	7/20	.3
	South Haven	Lake Michigan	Palisades	7/18	1.2
Minn:	Monticello	Mississippi River	Monticello	7/6	.5
Nebr:	Rulo	Missouri River	Fort Calhoun and Cooper	7/26	.7
Nev:	Boulder City	Colorado River	Background	7/10	1.0
N.J:	Bayside	Delaware River	Salem	7/5	0
N.Y:	Ossining	Hudson River	Indian Point	7/10	.3
	Oswego	Lake Ontario	Nine Mile Point and R. E. Ginna	7/5	.3
	Poughkeepsie	Hudson River	Background	7/12	.3
N.C:	Charlotte	Catawba River	Wm. B. McGuire	NS	
Oreg:	Westport	Columbia River	Rainier and Hanford	7/13	.5
S.C:	Allendale	Savannah River	Savannah River Plant and Oconee	[c] 6/28	2.0
	Hartsville	Lake Robinson	H. B. Robinson	7/7	2.2
Tenn:	Kingston	Clinch River	Oak Ridge	7/31	.9
Tex:	El Paso	Rio Grande	Los Alamos	7/5	.4
Vt:	Vernon	Connecticut River	Vermont Yankee	7/6	.3
Va:	Newport News	James River	Surry	7/5	0
Wash:	Northport	Columbia River	Background	7/12	.8
	Pasco	Columbia River	Hanford	7/6	.6
W. Va:	Wheeling	Ohio River	Shippingport	7/25	.3
Wisc:	Two Creeks	Lake Michigan	Point Beach and Kewaunee	7/12	.2
	Victory	Mississippi River	LaCrosse and Prairie Island	7/10	.4
	Average				0.6

[a] The minimum detection limit for all samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero.

[b] The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

[c] Sample collected early.

NS, no sample.

The highest individual concentration of tritium observed in the drinking water was 1.6 nCi/liter during the third quarter. This corresponds to a dose of 0.16 mrem/a, or less than 0.09 percent of the Federal Radiation Council's Radiation Protection Guide (170 mrem/a) for an average dose to a suitable sample of the exposed population.

The tritium concentrations for the surface water samples are given in table 2. The highest tritium concentration was 2.3 nCi/liter for the third quarter. Assuming that the specific activity of tritium in the body is essentially the same as that in surface water, this concentration corresponds to a dose of 0.23 mrem/a, or 0.14 percent of the Radiation Protection Guide.

The monthly analyses for tritium in precipitation samples at the 8 RAN stations are shown in table 3.

Table 3. Tritium concentration in precipitation from RAN stations, July-September 1972

Location		Tritium concentration [a] (nCi/liter ± 2σ)		
		July	August	September
Ala:	Montgomery	0	0	0
Alaska:	Anchorage	0	0	0
Colo:	Denver	0.5	0.4	0.2
Hawaii:	Honolulu	0	0	0
La:	New Orleans	0	0	0
N.C:	Gastonia	.2	NS	.2
Tex:	Austin	0	0	0
Wash:	Seattle	0	0	0

[a] The minimum detection limit for these samples was 0.20 nCi/liter. All values equal to or less than 0.20 nCi/liter before rounding have been reported as zero. The 2σ error for all samples is 0.2 nCi/liter unless otherwise noted.

NS, no sample.

Other coverage in *Radiation Data and Reports:*

Period	Issue
July-September 1971	April 1972
October-December 1971	May 1972
January-March 1972	August 1972
April-June 1972	January 1973

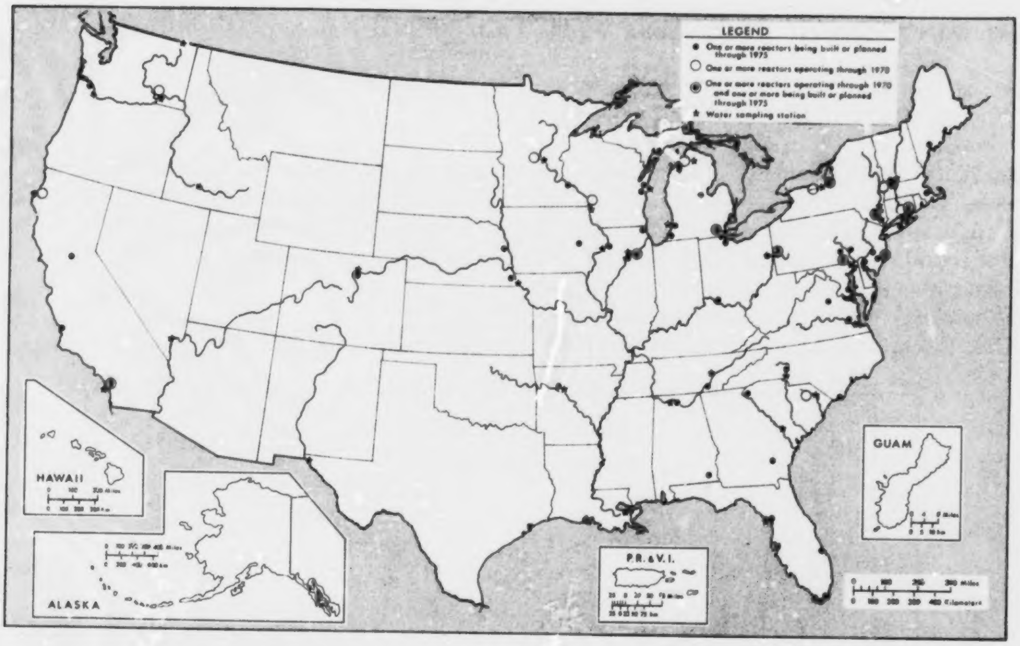
LEGEND
● One or more reactors being built or planned through 1975
○ One or more reactors operating through 1970
◉ One or more reactors operating through 1970 and one or more being built or planned through 1975
★ Water sampling station
HAWAII
ALASKA
GUAM
P.R. & V.I.

Figure 2. Surface water sampling locations for tritium surveillance system

REFERENCES

(1) BUREAU OF RADIOLOGICAL HEALTH. Tritium in surface water network, January-June 1970. Radiol Health Data Rep 11:638–639 (November 1970).

(2) BUREAU OF RADIOLOGICAL HEALTH. Tritium in precipitation (RAN), July-December 1969. Radiol Health Data Rep 11: 354–355 (July 1970).

(3) MOGHISSI, A. A. and C. R. PORTER. Tritium in surface waters in the United States, 1966. Radiol Health Data Rep 9: 337–339 (July 1968).

(4) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Recommendations of the International Commission on Radiological Protection (Adopted September 17, 1965), ICRP Publication 9 (1969).

(5) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Basic Radiation Protection Criteria, NCRP Report No. 39. National Council on Radiation Protection and Measurements, Washington, D.C. 20008 (January 15, 1971).

(6) INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Radiation quantities and units, ICRU Report No. 19, Washington, D.C. 20014 (July 1972).

109

Water Surveillance Programs, April-June 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the NERC-LV,[1] consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

---

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

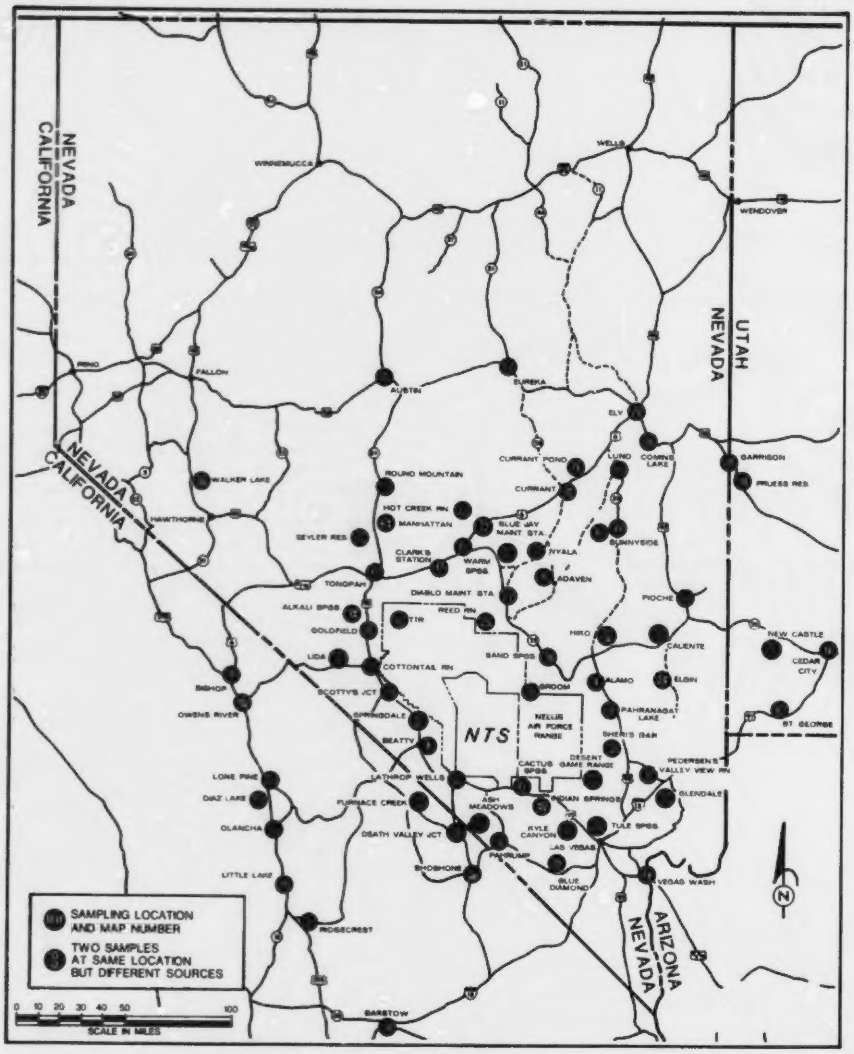
NEVADA
CALIFORNIA
UTAH
NEVADA
ARIZONA
NEVADA
WINNEMUCCA
WELLS
WENDOVER
RENO
FALLON
AUSTIN
EUREKA
ELY
GARRISON
PRUESS RES
CURRANT POND
LUND
COMINS LAKE
CURRANT
WALKER LAKE
HAWTHORNE
ROUND MOUNTAIN
HOT CREEK RN
MANHATTAN
BLUE JAY MAINT STA
GEYLER RES
CLARK'S STATION
WARM SPGS
NYALA
SUNNYSIDE
TONOPAH
DIABLO MAINT STA
ADAVEN
PIOCHE
ALKALI SPGS
REED RN
TTR
GOLDFIELD
HIKO
CALIENTE
NEW CASTLE
CEDAR CITY
LIDA
COTTONTAIL RN
SAND SPGS
ALAMO
ELGIN
BISHOP
SCOTTY'S JCT
GROOM
OWENS RIVER
SPRINGDALE
PAHRANAGAT LAKE
ST GEORGE
BEATTY
NTS
NELLIS AIR FORCE RANGE
SHERI'S BAR
LONE PINE
LATHROP WELLS
CACTUS SPGS
DESERT GAME RANGE
PEDERSEN'S
VALLEY VIEW RN
DIAZ LAKE
FURNACE CREEK
ASH MEADOWS
INDIAN SPRINGS
GLENDALE
OLANCHA
DEATH VALLEY JCT
KYLE CANYON
TULE SPGS
PAHRUMP
LAS VEGAS
SHOSHONE
LITTLE LAKE
BLUE DIAMOND
VEGAS WASH
N
RIDGECREST
BARSTOW
SAMPLING LOCATION AND MAP NUMBER
TWO SAMPLES AT SAME LOCATION BUT DIFFERENT SOURCES
0 10 20 30 40 50 100
SCALE IN MILES

Figure 1. NERC-LV water surveillance network

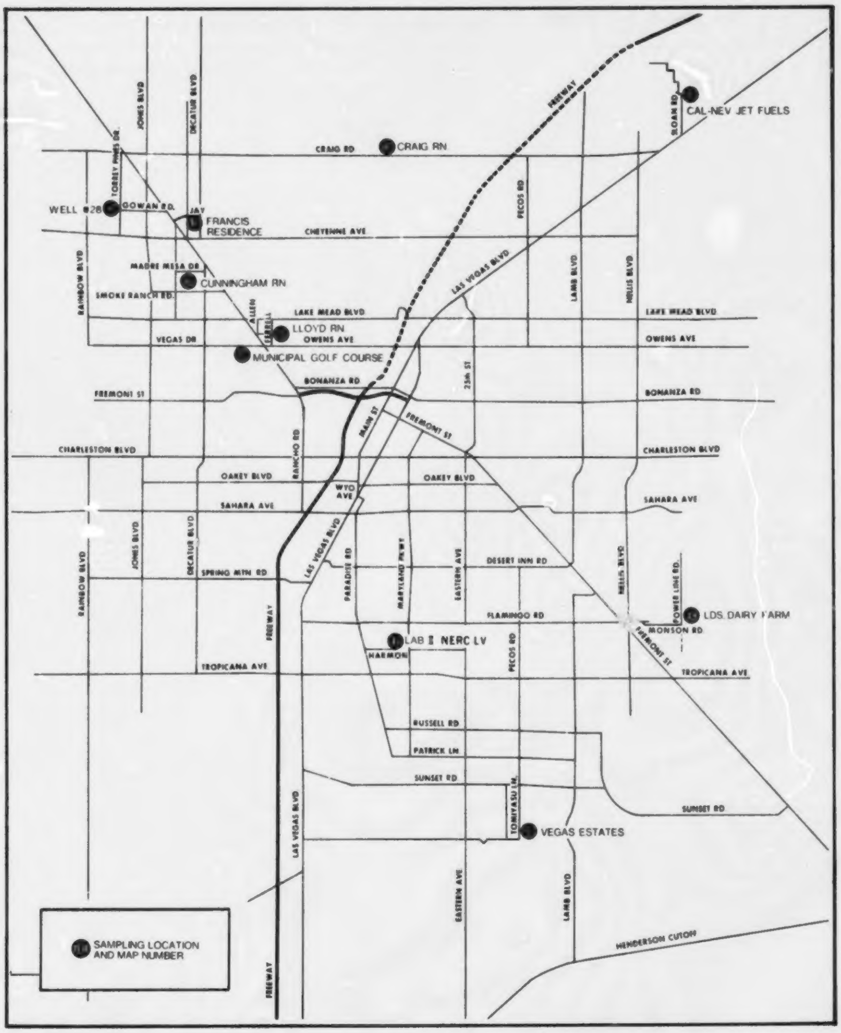
CAL-NEV JET FUELS
CRAIG RN
WELL #28
FRANCIS RESIDENCE
CUNNINGHAM RN
LLOYD RN
MUNICIPAL GOLF COURSE
LDS DAIRY FARM
LAB & NERC LV
VEGAS ESTATES
SAMPLING LOCATION AND MAP NUMBER
CRAIG RD
GOWAN RD
CHEYENNE AVE
MADRE MESA DR
SMOKE RANCH RD
LAKE MEAD BLVD
OWENS AVE
VEGAS DR
BONANZA RD
FREMONT ST
CHARLESTON BLVD
OAKEY BLVD
SAHARA AVE
DESERT INN RD
SPRING MTN RD
FLAMINGO RD
MONSON RD
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
HENDERSON CUTOFF
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
RANCHO RD
MAIN ST
LAS VEGAS BLVD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
PECOS RD
25th ST
LAMB BLVD
NELLIS BLVD
POWER LINE RD
SLOAN RD
TOMIYASU LN
FREEWAY
WYO AVE

Figure 2. Water surveillance network, Las Vegas valley

area is conducted to determine radionuclide concentrations and to take protective action, if required. Other sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports*.

Results

The analytical results of all water samples collected in April, May, and June 1972 by the NERC-LV Water Surveillance Network are listed in table 1, including three samples collected in Colorado in support of Project Rulison. No gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis.

Table 2. NERC-LV water surveillance results, April-June 1972

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish & Game Office	9	4/5	23	<2.8	<3.3	NA
		5/9	23	<1.3	<3.2	NA
		6/2	23	<2.4	<3.4	NA
Owens River, 3 miles East	10	4/5	22	5 ±4	4 ±3	NA
		5/9	22	5 ±3	5 ±3	NA
		6/2	22	<4.1	<3.4	NA
Death Valley Junction:						
Lila's Cafe	21	4/6	23	<6.5	10 ±3.8	<220
		5/10	23	<5.3	8 ±4	<220
		6/2	23	<8.8	9 ±4	<210
Furnace Creek:						
Pond	28	4/6	21	6 ±5	11 ±3.7	NA
		5/10	21	<3.7	9 ±4	NA
		6/2	21	<6.8	6 ±4	NA
Visitors Center	29	4/6	27	<6.3	8 ±4	NA
		5/10	27	4 ±4	11 ±3.8	NA
		6/2	27	<6.8	7 ±4	NA
Hinkley:						
Bill Nelson Dairy	39	4/3	23	<4.7	10 ±4	NA
		5/8	23	9 ±5	7 ±4	NA
		6/1	23	<6.9	6 ±4	NA
Little Lake:						
Little Lake Ranch	60	4/4	21	<8.7	24 ±4.7	NA
		5/8	21	<5.2	25 ±4.5	NA
		6/1	21	<8.3	<3.6	NA
Lone Pine:						
Diaz Lake	61	4/4	21	13 ±6.9	19 ±4.2	NA
		5/8	21	14 ±6.9	35 ±4.9	NA
		6/1	21	17 ±8.9	24 ±4.7	NA
Forest Service Ranger Station	62	4/5	23	<3.2	<3.3	NA
		5/8	23	<1.5	<3.2	NA
		6/1	23	<2.0	<3.2	NA
Olancha:						
Haiwee Reservoir	73	4/4	21	29 ±7.5	6 ±3	NA
		5/8	21	6 ±3	5 ±3	NA
		6/1	21	<3.9	9 ±4	NA
Ridgecrest:						
City Hall	76	4/4	23	<4.0	3 ±3	NA
		5/8	23	<2.7	<3.3	NA
		6/1	23	<5.6	9 ±4	NA
Shoshone:						
Chevron Service Station	79	4/6	27	<6.3	19 ±4.2	NA
		5/10	27	7 ±5	21 ±4.5	NA
		6/2	27	<8.2	15 ±4.3	NA
Colorado:						
Grand Valley:						
Battlement Creek above Test Well [c]		4/23	22	NA	NA	550 ±230
Battlement Creek [c]		4/23	22	NA	NA	710 ±230
Claude Hayward Cabin [c]		4/23	27	NA	NA	300 ±220
Nevada:						
Adaven:						
Canfield Ranch	1	4/5	22	5 ±3	4 ±3	NA
		5/3	22	5 ±3	4 ±3	NA
		6/1	22	<4	<3.4	NA
Alamo:						
Sheri's Bar	2	4/4	23	<4.4	<3.4	NA
		5/5	23	4 ±3	<3.3	NA
		6/2	23	<4	5 ±3	NA
Pahranagat Lake	3	4/4	21	17 ±8	18 ±4.3	NA
		5/5	21	11 ±5.8	21 ±4.4	NA
		6/1	21	15 ±7.9	30 ±4.7	NA
Williams Dairy	4	4/4	23	<5	13 ±3.8	NA
		5/5	23	<3.4	11 ±3.8	NA
		6/2	23	<5.7	15 ±3.9	NA
Ash Meadows:						
Ash Meadows Lodge	5	4/10	23	NA	NA	<220
		5/3	23	9 ±5	18 ±4.2	<210
		6/1	23	10 ±9	17 ±4.4	<200
Ash Meadows Pond	6	4/10	21	<7.5	27 ±4.7	NA
		5/3	21	12 ±6	23 ±5	NA
		6/1	21	NA	15 ±4	NA
Austin:						
County Court House	7	4/5	27	25 ±6.3	16 ±4	NA
		5/4	27	23 ±6.5	24 ±4.3	NA
		6/2	27	21 ±7.0	15 ±4.1	NA
Beatty:						
Richfield Service Station	8	4/6	23	11 ±6.4	9 ±4	<220
		5/2	23	13 ±7.4	12 ±3.9	<210
		6/1	23	<8.3	9 ±4	<200

See footnotes at end of table.

112

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Blue Diamond:						
Post Office	11	4/10	23	<4.2	<3.1	240 ±210
		5/5	23	6 ±4	3.2	<220
		6/2	23	<5.5	<3.5	<200
Blue Jay Highway Maintenance Station	12	4/5	23	5 ±4	8 ±4	NA
		5/3	23	9 ±4	6 ±3	NA
		6/1	23	<4.8	4 ±3	NA
Cactus Springs:						
Mobil Service Station	13	4/7	27	<3.9	<3.3	<210
		6/1	27	<3.4	<3.4	<220
Caliente:						
Agricultural Extension Station	14	4/4	23	6 ±4	5 ±3	NA
		5/3	23	12 ±4.8	4 ±3	NA
		6/1	23	<4.5	6 ±3	NA
Meadow Valley Wash	15	4/4	22	<6.3	15 ±4.2	NA
		5/3	22	9 ±5	14 ±4.0	NA
		6/1	22	<5.5	18 ±4.1	NA
Clark Station:						
Five Mile Ranch	17	4/5	27	<3.2	10 ±4	NA
		5/3	27	<2.8	7 ±3	NA
		6/1	27	<4.7	5 ±4	NA
Coyote Summit:						
Sand Spring Well	18	4/5	23	33 ±9.9	18 ±4.3	NA
		6/1	23	21 ±9.4	25 ±4.7	NA
Currant:						
Currant Pond	19	4/6	21	7 ±5	11 ±3.9	NA
		5/5	21	10 ±4.9	5 ±3	NA
		6/1	21	<5.4	<3.2	NA
Currant Ranch Cafe	20	4/6	27	22 ±7.5	28 ±4.8	NA
		5/7	27	6 ±4	8 ±3	NA
		6/1	27	6 ±5	7 ±3	NA
Diablo Highway Maintenance Station	22	4/5	23	<3.2	10 ±3.8	NA
		5/4	23	<2.9	5 ±3	NA
		6/1	23	<4	9 ±4	NA
Diablo:						
Reed Ranch	23	4/5	21	29 ±8.3	8 ±4	NA
		5/3	21	29 ±9.1	42 ±5.2	NA
		6/2	21	20 ±8.7	43 ±5.5	NA
Elgin:						
Water Tower	24	4/5	23	21 ±8.5	11 ±4	NA
		5/4	23	10 ±5.3	13 ±3.9	NA
		6/1	23	7 ±5	13 ±3.7	NA
Ely:						
Chevron Service Station	25	4/4	24	<3.3	<3.4	NA
		5/3	24	<2.3	<3.1	NA
		6/1	24	<3.4	<3.4	NA
Comins Lake	26	4/4	21	11 ±1	29 ±6	NA
		5/3	21	11 ±6.2	38 ±5.1	NA
		6/1	21	8 ±6	47 ±5.5	NA
Eureka:						
Chevron Service Station	27	4/6	24	<3.8	<3.4	NA
		5/3	24	<2.6	4 ±3	NA
		6/1	24	6 ±5	9 ±4	NA
Glendale:						
Chevron Service Station	32	4/4	27	<6.0	9 ±4	NA
		5/5	27	8 ±5	17 ±4.2	NA
		6/2	27	<5.8	18 ±3.9	NA
Muddy River	33	4/4	22	<7.8	8 ±4	NA
		5/5	22	7 ±5	24 ±4.6	NA
		6/1	22	<7.5	21 ±4.4	NA
Goldfield:						
Alkali Springs	34	4/3	21	29 ±11	46 ±5.7	NA
		5/3	21	<8.5	32 ±5.1	NA
		6/1	21	<10	28 ±5.2	NA
Chevron Service Station	35	4/8	23	<4.0	<3.4	NA
		5/3	23	<3.9	4 ±3	NA
		6/1	23	<6.1	<3.5	NA
Hawthorne:						
Walker Lake [e]	36	6/1	21	<22	300 ±26	NA
Hiko:						
Crystal Springs	37	4/4	27	5 ±4	4 ±3	NA
		5/2	27	8 ±4	8 ±4	NA
		6/2	27	4 ±3	8 ±3	NA
Schofield Dairy	38	4/4	23	19 ±7.8	25 ±4.5	NA
		5/2	23	36 ±9.7	35 ±5.0	NA
		6/2	23	26 ±9.9	36 ±5.0	NA
Indian Springs:						
Chevron Service Station	40	4/6	23	<3.1	<3.1	<220
		5/5	23	6 ±4	<3.1	<220
		6/1	23	<4.3	4 ±3	<200
Las Vegas:						
Cal-Nev Jet Fuels	41	4/10	23	<4.4	6 ±3	<220
		5/8	23	4 ±3	6 ±3	<220
		6/1	23	<3.4	3 ±3	<210

See footnotes at end of table.

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Craig Ranch Golf Course	42	4/10	23	8±4	5±3	<220
		5/8	23	7±4	5±3	<220
		6/1	23	5±4	5±3	<210
Cunningham Ranch	43	4/10	23	<2.9	<3.1	<220
		5/8	23	10±4	11±3.6	<220
		6/1	23	6±4	11±3.7	<210
Desert Game Range	44	4/7	23	6±4	7±3	<210
		5/5	23	7±4	5±3	<210
		6/1	23	<3.8	<3.4	<220
Desert Game Range Pond	45	4/7	21	<2.9	4±3	<220
		5/5	21	<3.7	4±3	NA
		6/1	21	<3.8	<3.4	<220
Francis Residence	46	4/10	23	<5.2	<3.2	<220
		5/8	23	6±5	<3.2	<220
		6/1	23	<5.8	<3.3	<210
Lab II, NERC-LV	47	4/10	24	<7.2	8±4	980±230
		5/8	24	9±6	12±3.8	1,100±210
		6/1	24	<6.0	11±3.8	1,000±220
Lake Mead Vegas Wash	48	4/10	21	<5.6	5±3	870±230
		5/9	21	<5.6	7±3	1,100±210
		6/1	21	<5.9	11±3.8	1,100±220
LDS Dairy Farm	49	4/11	23	<13	<4.0	<220
		5/9	23	<8.4	13±4.1	<200
		6/1	23	14±10	15±4.4	<210
Lloyd Ranch	50	4/10	23	11±7.9	4±3	<220
		5/8	23	7±6	9±4	<220
		6/1	23	<6.0	8±4	<210
L V Water District Well 28	51	4/10	23	<4.2	<3.3	<220
		5/8	23	13±4.9	5±3	<220
		6/1	23	<3.3	<3.2	<210
Municipal Golf Course	52	4/10	23	<4.3	<3.3	<210
		5/8	23	5±3	11±3.6	<220
		6/1	23	<3.3	5±3	<210
Tule Springs	53	4/7	23	<2.8	<3.1	<210
		5/5	23	4±3	4±3	<220
		6/1	23	<3.6	<3.4	<220
Tule Springs Pond	54	4/7	21	13±4.7	6±3	NA
		5/5	21	3±3	<3.1	NA
		6/1	21	<3.8	<3.4	NA
Vegas Estates	55	4/10	23	<8.2	8±4	<210
		5/8	23	<5.9	12±3.8	<220
		6/1	23	<6.6	12±3.9	<210
Lathrop Wells:						
Texaco Service Station	56	4/6	23	<4.1	4±3	<220
		5/2	23	<3.6	<3.2	<210
		6/1	23	<5.4	<3.5	<220
Lida Junction:						
Cottontail Ranch	57	4/3	23	5±4	15±4.1	NA
		5/5	23	<3.3	15±4.0	NA
		6/1	23	<4.2	15±4.0	NA
Lida:						
Lida Livestock Company	58	4/3	27	<2.9	<3.3	NA
		5/5	27	<3.6	8±3	NA
		6/1	27	<4.8	<3.4	NA
Pond at Storage Tank	59	4/3	21	14±5.8	6±4	NA
		5/5	21	<3.5	4±3	NA
		6/9	21	<4.5	<3.4	NA
Lund:						
Gardner Grocery	63	4/5	23	15±5.8	12±3.9	NA
		5/4	23	<2.7	<3.1	NA
		6/2	23	<4.1	5±3	NA
Manhattan:						
Country Store	64	4/5	23	19±7.3	6±4	NA
		5/4	23	20±7.7	5±3	NA
		6/2	23	13±7.7	12±4	NA
Seyler Reservoir	65	4/5	21	14±5.7	36±5	NA
Mercury:						
Groom Lake	66	4/4	23	<2.9	<3.3	NA
		5/2	23	<2.7	4±3	NA
		6/2	23	<5.1	4±3	NA
Moapa:						
Pedersen Valley View Ranch	67	4/4	27	<5.9	5±4	NA
		5/5	27	6±5	16±4	NA
		6/2	27	<6.8	10±4	NA
Mt. Charleston:						
Kyle Canyon Fire Station	68	5/5	27	<3.1	<3.1	280±220
		6/1	27	4±3	<3.1	<220
Kyle Canyon Pond	69	4/7	21	<2.7	<3.1	NA
		5/5	21	5±3	7±3	NA
		6/1	21	<3.3	11±3.6	NA
Nyala:						
Sharp's Ranch	72	4/5	23	<2.7	<3.3	NA
		5/3	23	<2.6	<3.1	NA
		6/1	23	<4.0	5±3	NA

See footnotes at end of table.

114

Table 2. NERC-LV water surveillance results, April-June 1972—continued

Location	Map number	Date collected (1972)	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada (continued)						
Pahrump:						
Texaco Service Station	74	4/10	23	<4.6	<3.3	<210
		5/3	23	<3.9	<3.2	NA
		6/2	23	4±3	<3.3	NA
Pioche:						
County Courthouse	75	4/5	24	<3.8	<3.4	NA
		5/3	24	<2.2	6±3	NA
		6/1	24	<3.5	6±3	NA
Round Mt:						
Mobile Service Station	77	4/5	27	14±5.0	<3.4	NA
		5/4	27	<3.1	5±3	NA
		6/2	27	<3.2	<3.4	NA
Scotty's Junction:						
Chevron Service Station	78	4/3	23	<4.7	9±4	<210
		5/5	23	6±5	13±4.0	<210
		6/1	23	<7	9±4	<220
Springdale:						
Peacock Ranch	80	4/12	27	<6.6	5±4	<210
		5/4	27	<4.3	8±3	<220
		6/2	27	<4.2	9±4	<220
Pond	81	4/12	21	<5.3	10±4	NA
		5/4	21	5±4	6±4	NA
		6/2	21	<6.6	10±3.9	NA
Sunnyside:						
Adam McGill Reservoir	83	4/5	21	8±5	4±3	NA
		5/4	21	7±4	7±3	NA
		6/2	21	<4.2	8±3	NA
Wildlife Management Headquarters	84	4/5	27	<3.4	<3.4	NA
		5/4	27	2±2	5±3	NA
		6/2	27	<3.9	<3.1	NA
Tonopah:						
Jerry's Chevron Station	85	4/4	23	4±3	13±3.9	NA
		5/4	23	6±4	7±3	NA
		6/1	23	<4.8	5±4	NA
Tonopah Test Range CP-1	86	4/4	23	10±6	10±4	NA
		5/3	23	<5.1	10±3.7	NA
		6/1	23	<5.6	6±4	NA
Warm Springs:						
Fallini's Pond	87	4/5	21	38±13	78±7.1	NA
		5/3	21	27±11	78±7.0	NA
		6/1	21	20±12	59±6.5	NA
Hot Creek Ranch	88	4/5	27	<4.8	9±4	NA
		5/3	27	<4.1	10±3.7	NA
		6/1	27	<7.5	9±4	NA
Service Station and Cafe	89	4/5	27	20±8.5	24±4.7	NA
		5/3	27	13±6.9	23±4.4	NA
		6/1	27	9±7	24±4.6	NA
Twin Springs Ranch	90	4/5	23	7±5	13±4.0	NA
		5/3	23	7±4	11±3.7	NA
		6/1	23	<5.7	10±3.9	NA
Utah:						
Cedar City:						
M. D. Baldwin Residence	16	4/5	24	<3.7	<3.4	NA
		5/3	24	2±2	<3.3	NA
		6/1	24	3±3	5±3	NA
Garrison:						
Pruess Reservoir [c]	30	6/2	21	11±6.5	15±3.9	NA
Rowley Grocery	31	4/4	23	6±4	9±4	NA
		5/8	23	5±4	6±3	NA
		6/2	23	<4.5	3±3	NA
Newcastle:						
Municipal Reservoir	70	4/5	21	21±7.1	20±4.4	NA
		5/3	21	9±4	11±3.8	NA
		6/1	21	10±5	10±4	NA
Newcastle Dairy	71	4/6	24	<5.4	<3.5	NA
		5/3	24	4±4	7±4	NA
		6/2	24	<5.1	8±4	NA
St. George:						
R. Cox Dairy	82	4/5	24	<2.6	<3.4	NA
		5/4	24	4±3	4±3	NA
		6/2	24	3±3	<3.1	NA

[a] Two-sigma counting error provided when available.

[b] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water, such as well and spring).
27—Spring.

[c] Quarterly samples.
NA, no analysis.
NS, no sample.

115

For the purpose of identifying the source of the gross radioactivity in all network samples and comparing sample concentrations with both AEC Concentration Guides and the PHS Drinking Water Standards, selected samples will be given special analyses at least once a year beginning with samples taken during calendar year 1972. For surface water samples, the special analyses will include strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226. For drinking water samples, the analyses will include strontium-89, strontium-90, uranium, and radium-226. The results of these special analyses will be reported at a later date.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

116

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Mexican air monitoring program	May-August 1972	January 1973
Plutonium in airborne particulates	April-June 1972	January 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January-December 1969	February 1972

117

1. Radiation Alert Network
October 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1972.

All other field estimates reported were within normal limits for the reporting station.

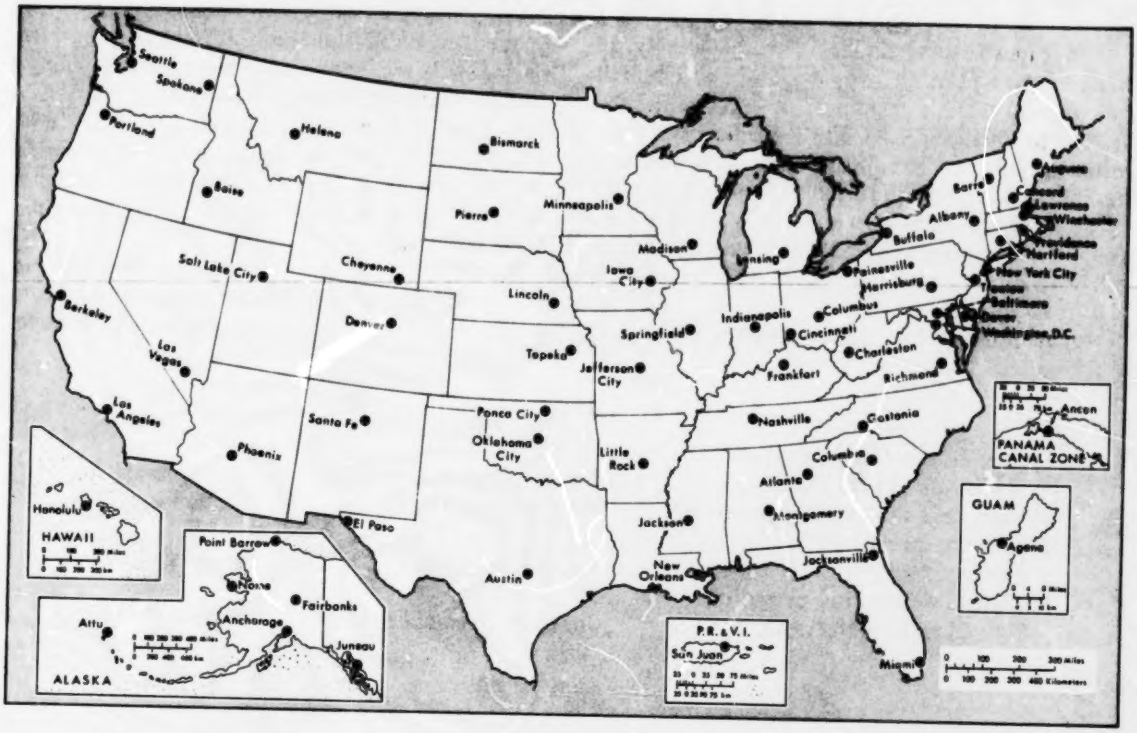
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Cheyenne
Salt Lake City
Madison
Lansing
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Washington, D.C.
Painesville
Harrisburg
Iowa City
Lincoln
Denver
Berkeley
Las Vegas
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Topeka
Jefferson City
Frankfort
Richmond
Los Angeles
Ponca City
Santa Fe
Nashville
Gastonia
Oklahoma City
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
Miles
Kilometers

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Precipitation			
			Maximum	Minimum	Average [a]		Total depth (mm)	Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	2	0	1	4	59	4	59	9
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	31	0	0	0	0				
	Fairbanks	0	------	------	------	0				
	Juneau	0	------	------	------	0				
	Nome	0	------	------	------	0				
	Point Barrow	0	------	------	------	0				
Ariz:	Phoenix	17	7	0	0	2				
Ark:	Little Rock	17	2	0	1	0				
Calif:	Berkeley	19	1	0	0	5	89	5	89	8
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	11	0	0	0	0				
Colo:	Denver	20	8	1	3	0		(b)		
Conn:	Hartford	19	2	0	0	6	49	6	49	0
Del:	Dover	18	1	0	0	0				
D.C:	Washington	22	2	0	0	0				
Fla:	Jacksonville	20	1	0	0	7	145	7	145	1
	Miami	0	------	------	------	0				
Ga:	Atlanta	12	2	1	1	0				
Guam:	Agana	0	------	------	------	0				
Hawaii:	Honolulu	20	1	0	0	3	54	(b)		
Idaho:	Boise	20	3	0	1	1	6	1	6	2
Ill:	Springfield	0	------	------	------	0				
Ind:	Indianapolis	19	1	0	0	0				
Iowa:	Iowa City	22	3	0	1	2	17	2	17	0
Kans:	Topeka	20	5	0	2	6	40	6	40	0
Ky:	Frankfort	14	2	0	1	0				
La:	New Orleans	21	1	0	0	3	159	(')		
Maine:	Augusta	21	1	0	0	6	138	6	138	0
Md:	Baltimore	20	3	0	1	6	43	6	43	0
Mass:	Lawrence	20	2	0	0	3	71	3	71	0
	Winchester	20	3	0	1	6	86	6	86	0
Mich:	Lansing	21	2	0	0	5	65	5	65	9
Minn:	Minneapolis	20	2	0	1	6	72	6	72	10
Miss:	Jackson	15	2	0	1	3	72	3	72	0
Mo:	Jefferson City	20	5	0	1	3	22	3	22	0
Mont:	Helena	16	4	0	1	1	2	1	2	0
Nebr:	Lincoln	9	11	1	3	2	68	2	68	10
Nev:	Las Vegas	20	4	0	1	0				
N.H:	Concord	0	------	------	------	0				
N.J:	Trenton	19	2	0	0	6	147	6	147	1
N. Mex:	Santa Fe	19	2	0	1	4	37	4	37	0
N.Y:	Albany	4	2	0	1	0				
	Buffalo	19	1	0	0	0				
	New York City	0	------	------	------	0				
N.C:	Gastonia	20	10	1	3	2	12	(b)		
N. Dak:	Bismarck	19	5	0	2	4	63	4	64	3
Ohio:	Cincinnati	0	------	------	------	0				
	Columbus	3	1	0	0	0				
	Painesville	22	1	0	0	7	76	7	76	17
Okla:	Oklahoma City	2	3	2	2	0				
	Ponca City	5	9	1	3	0				
Oreg:	Portland	21	1	0	0	4	28	4	28	4
Pa:	Harrisburg	18	3	0	1	0				
P.R:	San Juan	1	3	3	3	0				
R.I:	Providence	17	2	0	0	0				
S.C:	Columbia	13	6	0	1	3	41	3	41	0
S. Dak:	Pierre	20	9	1	3	0				
Tenn:	Nashville	16	2	0	1	8	109	8	109	0
Tex:	Austin	20	6	0	2	2	70	(b)		
	El Paso	22	5	0	2	0				
Utah:	Salt Lake City	27	3	0	1	7	95	7	95	17
Vt:	Barre	15	5	0	1	4	62	4	62	4
Va:	Richmond	16	1	0	0	1	54	1	54	10
Wash:	Seattle	9	0	0	0	2	11	(b)		
	Spokane	18	3	0	1	0				
W. Va:	Charleston	21	2	0	1	7	82	7	82	12
Wisc:	Madison	22	1	0	0	5	64	5	64	4
Wyo:	Cheyenne	16	8	0	3	0				
Network summary		1,010	11	0	1	144	76	5	66	4

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] October 1972

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for October 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	5	0.0	0.0	0.0	22	0.4
Coral Harbour	5	.0	.0	.0	14	.5
Edmonton	5	.0	.0	.0	70	.4
Ft. Churchill	5	.0	.0	.0	13	.4
Fredericton	5	.0	.0	.0	7	1.0
Goose Bay	5	.0	.0	.0	16	1.0
Halifax	5	.0	.0	.0	8	1.5
Inuvik	5	.0	.0	.0	30	1.2
Montreal	5	.0	.0	.0	8	.7
Moosonee	5	.0	.0	.0	NS	NS
Ottawa	5	.0	.0	.0	11	.9
Quebec	4	.0	.0	.0	30	3.9
Regina	5	.0	.0	.0	30	.3
Resolute	5	.0	.0	.0	29	.1
St. John's, Nfld	4	.0	.0	.0	10	1.5
Saskatoon	5	.0	.0	.0	31	.3
Sault Ste. Marie	5	.0	.0	.0	18	.8
Thunder Bay	5	.0	.0	.0	6	.3
Toronto	5	.0	.0	.0	12	1.1
Vancouver	5	.0	.0	.0	14	.9
Whitehorse	5	.0	.0	.0	64	1.0
Windsor	NS				12	.8
Winnipeg	5	.0	.0	.0	17	.4
Yellowknife	3	.0	.0	.0	17	.6
Network summary	111	0.0	0.0	0.0	21	0.9

NS, no sample available.

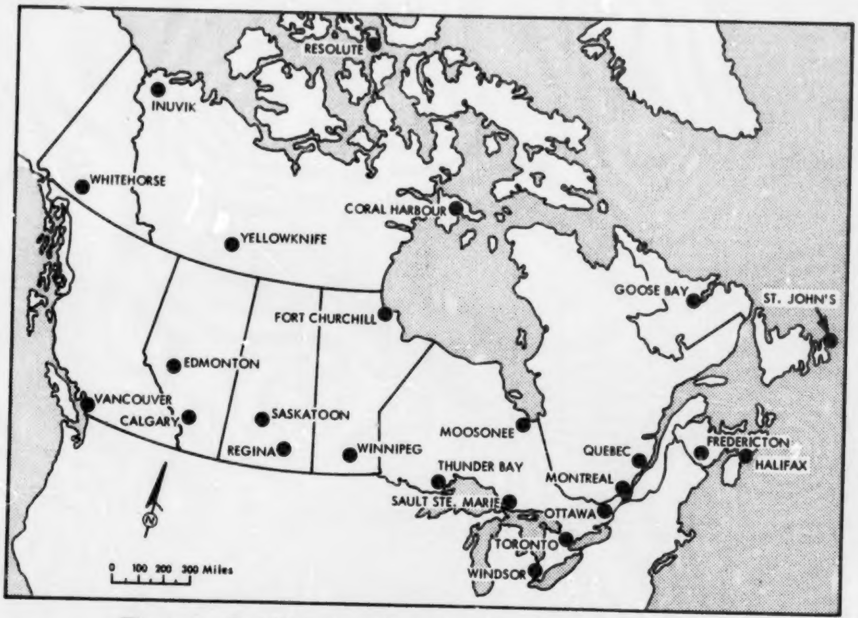
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
N
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program
October 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The locations of the air sampling stations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports.* The October 1972 air monitoring results from the participating countries are given in table 3.

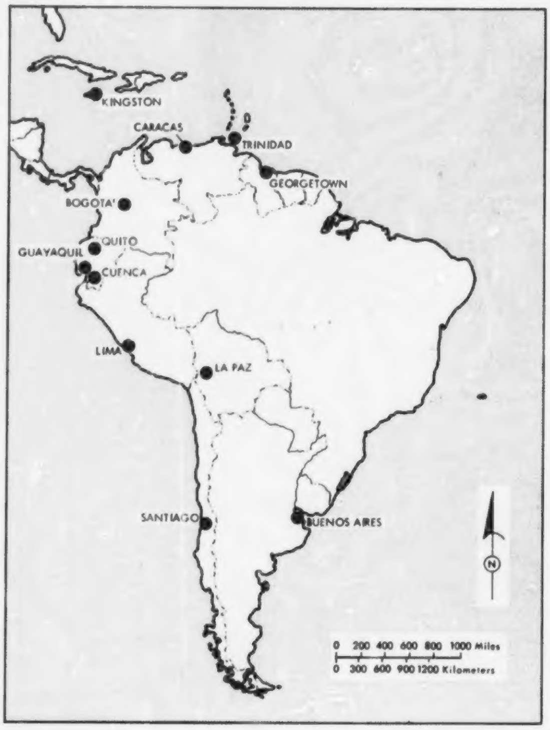

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, October 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	11	0.04	0.00	0.03
Chile:	Santiago	30	.13	.01	.04
Colombia:	Bogota	21	.02	.00	.01
Ecuador:	Cuenca	0			
	Guayaquil	13	.04	.01	.02
	Quito	16	.01	.00	.00
Guyana:	Georgetown	0			
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	10	.01	.00	.00
West Indies:	Trinidad	8	.07	.01	.03
Pan American summary		109	0.13	0.00	0.02

[a] The monthly average is calculated by weighing the indivdual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging 0.00 pCi/m³.

4. California Air Sampling Program
October 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

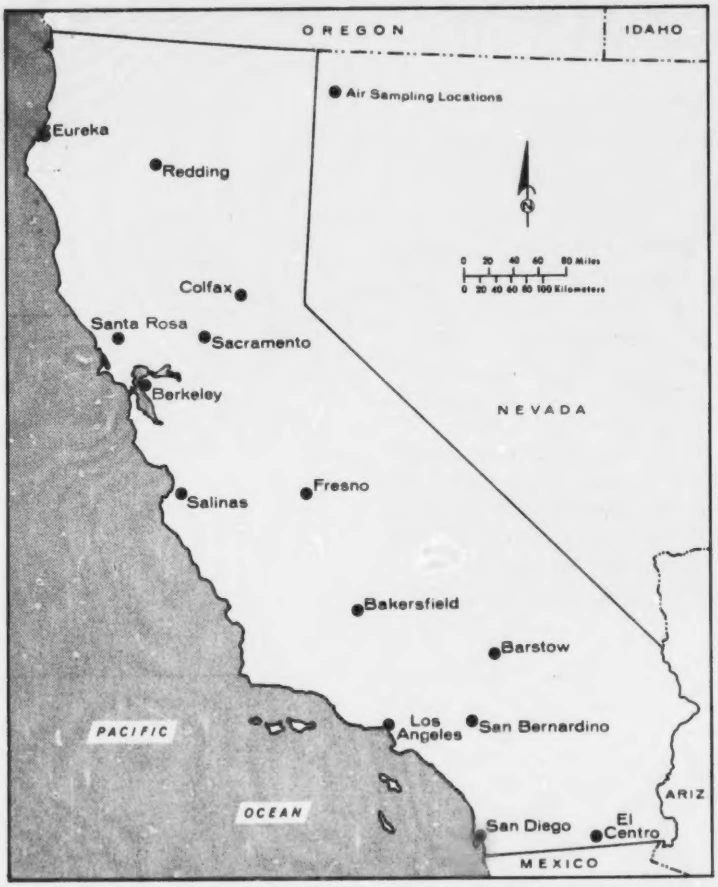
OREGON
IDAHO
● Air Sampling Locations
N
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ
San Diego
El Centro
MEXICO

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for October 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air October 1972

Station location	Number of samples	Gross beta radioactivity [a] (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	31	0.85	0.01	0.13
Barstow	31	.70	.03	.18
Berkeley	29	.24	.01	.08
Colfax	19	.40	.00	.11
El Centro	29	1.14	.01	.16
Eureka	31	.18	.00	.06
Fresno	31	1.57	.03	.22
Los Angeles	31	.17	.03	.08
Redding	29	.32	.03	.09
Sacramento	31	.46	.00	.12
Salinas	31	1.39	.01	.28
San Bernardino	28	.85	.01	.16
San Diego	29	.47	.04	.12
Santa Rosa	31	.24	.01	.08
Summary	411	1.57	0.00	0.13

[a] Single sample taken at Orange, Calif., October 31, 1972, resulted in a gross beta activity of 0.07. This sample is not included in summary.

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

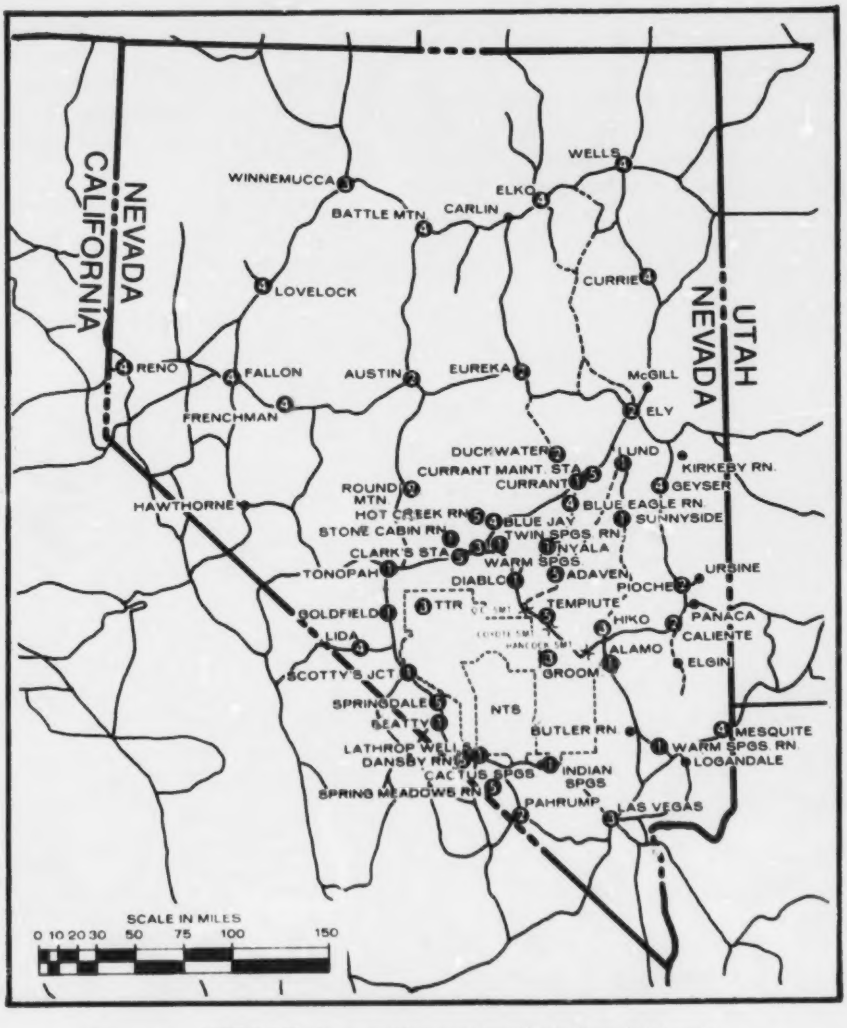
NEVADA
CALIFORNIA
UTAH
NEVADA
WELLS
WINNEMUCCA
ELKO
BATTLE MTN
CARLIN
CURRIE
LOVELOCK
RENO
FALLON
AUSTIN
EUREKA
McGILL
ELY
FRENCHMAN
DUCKWATER
LUND
KIRKEBY RN.
CURRANT MAINT. STA
CURRANT
GEYSER
ROUND MTN
BLUE EAGLE RN.
HAWTHORNE
HOT CREEK RN
BLUE JAY
SUNNYSIDE
STONE CABIN RN
TWIN SPGS. RN.
NYALA
CLARK'S STA
WARM SPGS
TONOPAH
ADAVEN
URSINE
DIABLO
PIOCHE
TEMPIUTE
GOLDFIELD
TTR
HIKO
PANACA
CALIENTE
LIDA
ALAMO
GROOM
ELGIN
SCOTTY'S JCT
SPRINGDALE
NTS
BEATTY
BUTLER RN
MESQUITE
LATHROP WELLS
WARM SPGS. RN.
LOGANDALE
DANSBY RN
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV air surveillance network stations in Nevada

Air Surveillance Network, October 1972

National Environmental Research Center—
Las Vegas,[1] *Environmental Protection Agency*

The Air Surveillance Network, operated by the National Environmental Research Center—Las Vegas, (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was 0.5 pCi/m^3 at Las Vegas, Nev. The minimum reporting concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations

---

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

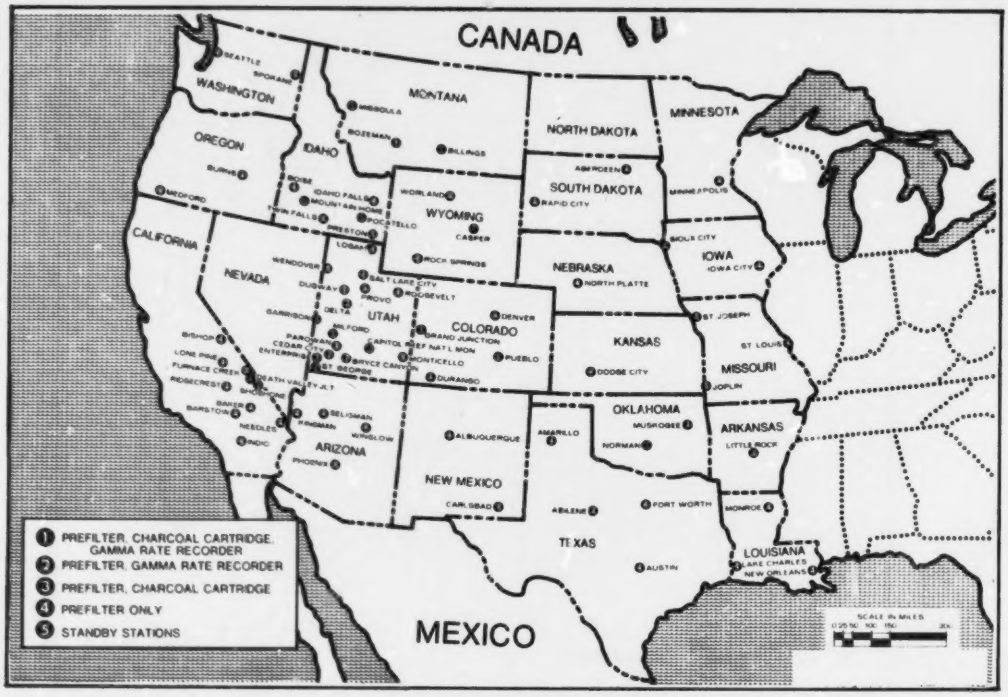
CANADA
MEXICO
WASHINGTON
SEATTLE
SPOKANE
OREGON
BURNS
MEDFORD
IDAHO
BOISE
IDAHO FALLS
MOUNTAIN HOME
TWIN FALLS
POCATELLO
PRESTON
MONTANA
MISSOULA
BOZEMAN
BILLINGS
WYOMING
WORLAND
CASPER
ROCK SPRINGS
CALIFORNIA
BISHOP
LONE PINE
FURNACE CREEK
RIDGECREST
BAKER
BARSTOW
NEEDLES
INDIO
NEVADA
DEATH VALLEY JCT
SHOSHONE
UTAH
LOGAN
WENDOVER
DUGWAY
SALT LAKE CITY
PROVO
ROOSEVELT
DELTA
GARRISON
MILFORD
PAROWAN
CEDAR CITY
ENTERPRISE
ST GEORGE
CAPITOL REEF NAT'L MON
BRYCE CANYON
MONTICELLO
ARIZONA
KINGMAN
SELIGMAN
WINSLOW
PHOENIX
COLORADO
DENVER
GRAND JUNCTION
PUEBLO
DURANGO
NEW MEXICO
ALBUQUERQUE
CARLSBAD
NORTH DAKOTA
SOUTH DAKOTA
ABERDEEN
RAPID CITY
NEBRASKA
NORTH PLATTE
KANSAS
DODGE CITY
OKLAHOMA
MUSKOGEE
NORMAN
TEXAS
AMARILLO
ABILENE
FORT WORTH
AUSTIN
MINNESOTA
MINNEAPOLIS
IOWA
SIOUX CITY
IOWA CITY
MISSOURI
ST JOSEPH
ST LOUIS
JOPLIN
ARKANSAS
LITTLE ROCK
LOUISIANA
MONROE
LAKE CHARLES
NEW ORLEANS
① PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
② PREFILTER, GAMMA RATE RECORDER
③ PREFILTER, CHARCOAL CARTRIDGE
④ PREFILTER ONLY
⑤ STANDBY STATIONS
SCALE IN MILES
0 25 50 100 150 200

Figure 2. NERC-LV air surveillance network stations outside Nevada

Table 1. Summary of gross beta radioactivity concentrations in air October 1972

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	31	0.4	<0.1	0.1
	Phoenix	29	.2	<.1	.1
	Seligman	31	<.1	<.1	.1
	Winslow	31	<.1	<.1	.1
Ark:	Little Rock	19	.1	<.1	.1
Calif:	Baker	31	<.1	<.1	.1
	Barstow	31	<.1	<.1	.1
	Berkeley	1	<.1	<.1	.1
	Bishop	31	<.1	<.1	.1
	Death Valley Junction	29	<.2	<.1	.1
	Furnace Creek	31	<.1	<.1	.1
	Indio	31	.2	<.1	.1
	Lone Pine	31	<.1	<.1	.1
	Needles	27	<.2	<.1	.1
	Ridgecrest	31	<.1	<.1	.1
	Shoshone	31	<.1	<.1	.1
Colo:	Denver	20	.1	<.1	.1
	Durango	6	<.1	<.1	.1
Idaho:	Boise	29	<.1	<.1	.1
	Idaho Falls	22	.1	<.1	.1
	Preston	30	.1	<.1	.1
	Twin Falls	31	.1	<.1	.1
Iowa:	Iowa City	20	<.1	<.1	.1
	Sioux City	25	.1	<.1	.1
Kans:	Dodge City	31	<.1	<.1	.1
La:	Lake Charles	21	<.1	<.1	.1
	Monroe	16	<.1	<.1	.1
	New Orleans	20	<.1	<.1	.1
Minn:	Minneapolis	20	<.1	<.1	.1
Mo:	Joplin	31	.1	<.1	.1
	St. Joseph	31	.1	<.1	.1
	St. Louis	31	<.1	<.1	.1
Nebr:	North Platte	25	<.1	<.1	.1
Nev:	Alamo	30	<.1	<.1	.1
	Austin	25	<.1	<.1	.1
	Battle Mountain	29	<.1	<.1	.1
	Beatty	31	<.2	<.1	.1
	Blue Eagle Ranch (Currant)	31	<.1	<.1	.1
	Blue Jay	31	.3	<.1	.1
	Caliente	29	<.1	<.1	.1
	Currant Ranch	31	<.1	<.1	.1
	Currie	30	<.1	<.1	.1
	Diablo	31	.4	<.1	.1
	Duckwater	26	<.1	<.1	.1
	Elko	31	<.1	<.1	.1
	Ely	30	<.1	<.1	.1
	Eureka	31	<.1	<.1	.1
	Fallini's Twin Springs Ranch	31	.1	<.1	.1
	Fallon	31	.2	<.1	.1
	Frenchman Station	31	.1	<.1	.1
	Geyser Maintenance Station	26	<.1	<.1	.1
	Goldfield	27	<.1	<.1	.1
	Groom Lake	31	.1	<.1	.1
	Hiko	30	<.1	<.1	.1
	Indian Springs	31	<.1	<.1	.1
	Las Vegas	21	.5	<.1	.1
	Lathrop Wells	29	<.1	<.1	.1
	Lida	31	<.1	<.1	.1
	Lovelock	31	<.1	<.1	.1
	Lund	32	<.4	<.1	.1
	Mesquite	31	<.1	<.1	.1
	Nyala	32	<.5	<.1	.1
	Pahrump	22	<.1	<.1	.1
	Pioche	31	<.1	<.1	.1
	Reno	31	.1	<.1	.1
	Round Mountain	31	<.1	<.1	.1
	Scotty's Junction	30	<.1	<.1	.1
	Stone Cabin Ranch	31	<.1	<.1	.1
	Sunnyside	28	<.1	<.1	.1
	Tonopah	31	.4	<.1	.1
	Tonopah Test Range	28	<.1	<.1	.1
	Warm Springs	2	<.1	<.1	.1
	Warm Springs Ranch	31	<.1	<.1	.1
	Wells	30	<.2	<.1	.1
	Winnemucca	30	<.1	<.1	.1
N. Mex:	Albuquerque	21	<.2	<.1	.1
	Carlsbad	30	<.1	<.1	.1
Okla:	Muskogee	31	<.2	<.1	.1
Oreg:	Burns	30	<.1	<.1	.1
	Medford	27	<.1	<.1	.1
S. Dak:	Aberdeen	31	<.1	<.1	.1
	Rapid City	26	<.1	<.1	.1
Tex:	Abilene	29	.2	<.1	.1
	Amarillo	31	.1	<.1	.1
	Austin	20	.1	<.1	.1
	Fort Worth	30	.1	<.1	.1

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, October 1972—continued

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Utah:	Bryce Canyon	17	<.1	<.1	.1
	Cedar City	29	<.2	<.1	.1
	Delta	31	<.2	<.1	.1
	Dugway	31	<.1	<.1	.1
	Enterprise	31	<.1	<.1	.1
	Garrison	31	<.1	<.1	.1
	Logan	29	.1	<.1	.1
	Milford	31	.1	<.1	.1
	Monticello	31	<.1	<.1	.1
	Parowan	30	<.1	<.1	.1
	Provo	30	<.1	<.1	.1
	Roosevelt	31	<.1	<.1	.1
	Salt Lake City	30	<.1	<.1	.1
	St. George	31	<.1	<.1	.1
	Wendover	31	.1	<.1	.1
Wash:	Seattle	20	<.1	<.1	.1
	Spokane	18	.1	<.1	.1
Wyo:	Rock Springs	31	.2	<.1	.1
	Worland	31	<.1	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reported value of 0.1 pCi/m³ is reported as <0.1.

which are below the minimum detectable concentration (0.06 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m³) are reported as <0.1 pCi/m³. From gamma spectrometry results, 0.1 pCi/m³ of ruthenium-103 was identified on one filter collected on October 3, 1972, at Boise, Idaho. No other radionuclides were identified on any filters or charcoal cartridges during October 1972.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for the Brookhaven National Laboratory.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory[2]
July-December 1970

Associated Universities, Inc.
Upton, N.Y.

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by radioactivity in the cooling air from the research reactors (2) by radiation from an ecology forest gamma-ray source, and (3) by low-level radioactive liquid wastes released to a stream that forms one of the headwaters of the Peconic River (figure 1). The radiation levels resulting from reactor air effluent and the ecology forest source are monitored continuously by four stations located at the site boundary. The liquid

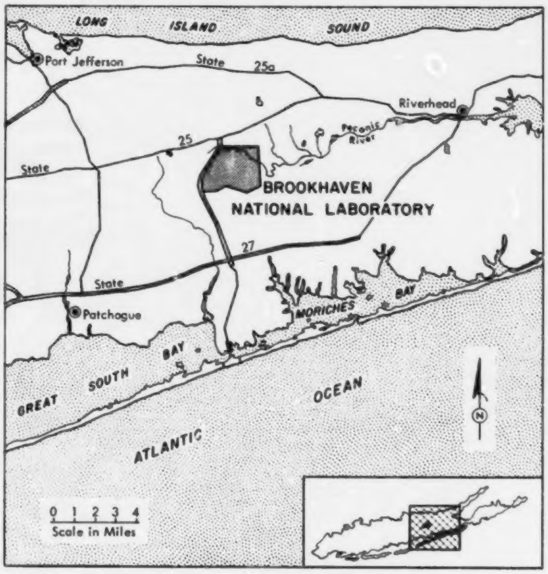

Figure 1. Brookhaven National Laboratory and surrounding area

---

[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the First Half of 1970," Associated Universities Inc., Upton, N.Y. 11973.

waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the site.

Area monitoring

The average weekly radiation levels at the Brookhaven National Laboratory site perimeter (figure 2), due to laboratory operations, are given in table 1. Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to a cesium-137 source located in the nearby forest. The radiation levels at this location were only 3.5 percent of the established Atomic Energy Commission (AEC) radiation protection standard of 500 mrem/year for individuals in the general population. Values of radiation background levels undisturbed by laboratory operations also have been included in table 1 for purposes of comparison.

Air monitoring

No increments in air activity attributable to laboratory operations were detectable in the concentrations of gross beta radioactivity and no gamma-emitters attributable with laboratory stack releases were identifiable in any air particulate samples. The ambient background gross beta concentation was 0.17 pCi/m^3. The applicable AEC standard is 100 pCi/m^3. The radioiodine and tritium vapor concentrations were less than the lower limits of detection, which are 0.001 and 10 pCi/m^3, respectively.

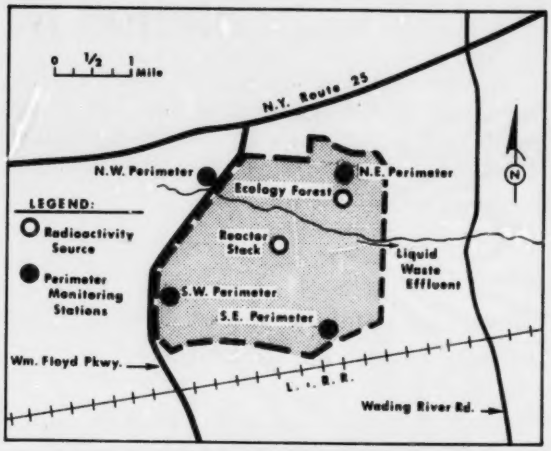

Figure 2. Brookhaven National Laboratory monitoring station locations

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the

Table 1. External gamma radioactivity at BNL site perimeter due to laboratory operations, July-December 1970 and annual summary 1970

1970	Average exposure rates (mR/week)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter [a]
July	0.00	0.00	0.00	0.38
August	.00	.00	.00	.38
September	.00	.00	.00	.34
October	.00	.00	.00	.35
November	.00	.00	.00	.33
December	.00	.00	.00	.30
Highest weekly reading (July–December)	0.00	0.00	0.00	0.40
Average undisturbed background (July–December)	2.00	2.01	1.83	1.79
Summary-January-June	.00	.00	.00	.29
July–December	.00	.00	.00	.35
January–December	.00	.00	.00	.32
Average undisturbed background (January–December)	1.77	1.89	1.73	1.78

[a] Levels measured continuously at station on former perimeter, 2,630 feet north of source have been adjusted on the basis of periodic measurements at the present perimeter, 3,405 feet north.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, July-December 1970

1970	Volume of flow (gallons/day)	Average beta radioactivity concentration (pCi/liter)	Total beta radioactivity concentration discharged (mCi)	Tritium concentration (nCi/liter)	Tritium radioactivity (Ci)
July	995,000	43	4.5	19	2.0
August	855,000	18	2.0	14	1.5
September	525,000	10	.6	8	.4
October	282,000	8	.3	18	.6
November	312,000	14	.6	4	.2
December	405,000	10	.5	7	.3
Summary:					
January-June	1,130,000	15	11.0	23	16.6
July-December	565,000	22	8.5	12	5.0
January-December	799,000	18	19.5	19	21.6

BNL site. The average concentation and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for July-December 1970.

Analysis of composite samples of the effluent has shown that, on the average, less than 20 percent of the radioactivity consists of strontium-90. No appreciable amounts of radioactive iodine or bone-seeking radionuclides (such as radium) other than strontium, were present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 1 nCi/liter averaged over a period of 1 year. The observed concentration in effluent was 2.2 percent of the standard.

Most gross beta measurement instruments are not sensitive to low energy beta emitters, such as tritium, for which special analytical methods must be employed. The concentration and amounts of tritium found during this reporting period in the laboratory's liquid waste effluent are also shown in table 2. The applicable AEC standard is 3 μCi/liter, averaged over a period of 1 year. The observed concentration of tritium at BNL was 0.4 percent of this standard.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-June 1970	December 1972

Reported Nuclear Detonations, January 1973

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations or seismic signals reported by the U.S. Atomic Energy Commission for January 1973.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

130

☆ U.S. GOVERNMENT PRINTING OFFICE: 1973—514-845/7

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

CALCULATIONS OF ENVIRONMENTAL RADIATION EXPOSURES AND POPULATION DOSES DUE TO EFFLUENTS FROM A NUCLEAR FUEL REPROCESSING PLANT. *J. A. Martin, Jr. Radiation Data and Reports, Vol. 14,* February 1973, pp. 59–76.

Effluent and environmental data pertinent to the Nuclear Fuel Services nuclear fuel reprocessing plant in West Valley, N. Y., were analyzed to determine doses to sample populations. Individual doses to the maximally exposed population group were considered. Population doses (man-rems) from the air, fish, deer, and water pathways were calculated. The most significant radionuclides contributing to doses were tritium, krypton-85, strontium-90, cesium-134 and cesium-137. It was concluded that the impact of this facility upon humans was well below applicable guides in 1971.

KEYWORDS: Effluent, exposure, fuel reprocessing plant, krypton-85, New York, population doses, tritium

ASSESSMENT OF DOSES IN THE WESTERN UNITED STATES FROM THE PEOPLE'S REPUBLIC OF CHINA NUCLEAR TEST OF JANUARY 7, 1972. *R. B. Evans, R. N. Snelling, and F. N. Buck. Radiation Data and Reports, Vol. 14,* February 1973, pp. 77–83.

Measurable increases in airborne radioactivity were detected in the western United States by the Air Surveillance Network (operated by the National Environmental Research Center-Las Vegas, EPA) following a nuclear detonation by the People's Republic of China on January 7, 1972. The progress and intensity of the radioactive cloud across the United States is presented graphically. The highest hypothetical infant thyroid dose equivalent calculated to result from the inhalation of iodine-131 and tellurium-132 was 1.2 mrem at Pueblo, Colorado.

KEYWORDS: Thyroid, iodine-131, nuclear detonation, tellurium-132, western United States, dose, airborne radioactivity

RADIATION DATA AND REPORTS

Volume 14, Number 3, March 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

- Department of Defense
- Department of Agriculture
- Department of Commerce
- Department of Health, Education, and Welfare
- Environmental Protection Agency
- Atomic Energy Commission

CONTENTS

Page

REPORTS

Radiobioassay Program of the Institutional Total Diet Sampling Network: I. Analytical Data Related to Samples Collected During 1966–1968 129

A. A. Moghissi, M. W. Carter, and R. Lieberman

State Environmental Radioactivity Surveillance Programs, 1972 145

M. A. Culliton

DATA

SECTION I. MILK AND FOOD 175

Milk Surveillance, November 1972 175

Milk Surveillance Programs, July–September 1972, *NERC-LV* 185

Food and Diet Surveillance 188

SECTION II. WATER 189

Gross Radioactivity in Surface Waters of the United States, June–September 1972 190

Water Surveillance Programs, July–September 1972, *NERC-LV* 195

132

CONTENTS—continued

Page

SECTION III. AIR AND DEPOSITION 202

Radioactivity in Airborne Particulates and Precipitation ... 202

1. Radiation Alert Network, November 1972 203
2. Canadian Air and Precipitation Monitoring Network, November 1972 205
3. Pan American Air Sampling Program, November 1972, *PAHO and EPA* 206
4. California Air Sampling Program, November 1972 ... 206
5. Plutonium in Airborne Particulates, July–September 1972 208

Air Surveillance Network, November 1972, *NERC-LV* 209

SECTION IV. OTHER DATA 213

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 213

1. Bettis Atomic Power Laboratory, January–December 1971 213
2. Mound Laboratory, July–December 1970 216

Nuclear Power Reactors in the United States, December 31, 1972 220

Reported Nuclear Detonations, February 1973 224

Synopses iii

Guide for Authors .... Inside back cover

RADIATION DATA AND REPORTS

Published under the direction of

W. D. Rowe
Deputy Assistant Administrator
for Radiation Programs

BOARD OF EDITORIAL ADVISORS

Capt. Myron I. Varon, MC, USN
Department of Defense

Dr. Milton W. Lammering
Environmental Protection Agency

Lee O. Tiffin
Department of Agriculture

Dr. Randall S. Caswell
Department of Commerce

Robert E. Simpson
Department of Health, Education, and Welfare

Dr. Martin B. Biles
Atomic Energy Commission

STAFF

Editor	Samuel Wieder
Managing Editor	Kurt L. Feldmann
Editorial Assistants	Jacqueline J. Copp Mary H. Nesdore
Illustrator	Marylee C. Hill

Address correspondence to the Editor, *Radiation Data and Reports*, Office of Radiation Program, Waterside Mall, E615, Washington, D.C. 20460.

For subscriptions to *Radiation Data and Reports*, please use the order form on last page of this issue.

U.S. ENVIRONMENTAL PROTECTION AGENCY
William D. Ruckelshaus, Administrator

Radiobioassay Program of the Institutional Total Diet Sampling Network: I. Analytical Data Related to Samples Collected During 1966–1968

A. A. Moghissi,[1] *M. W. Carter,*[2] *and R. Lieberman*[3]

In January 1966, a radiobioassay program was added to the Institutional Total Diet Sampling Network program. The sampling and analysis procedures are described and the data for 1966 through 1968 are presented.

There have been numerous measurements related to environmental radiation and the contribution of internally deposited radionuclides to the radiation dose in people. In recognition of the potential significance of the diet as a source of intake of radionuclides, the Institutional Total Diet Sampling Network program (ITDSN) was initiated in 1961 by certain components of the U.S. Public Health Service, which now reside in the Office of Radiation Programs, U.S. Environmental Protection Agency. The details of the program have been described by Anderson and Nelson (*1*) and the results have been published periodically in this journal.

The ITDSN assesses the radionuclide content of food consumed by certain groups of children from 6 to 18 years of age. Initially, eight institutions were selected. As experience was gained, its scope was increased to boarding schools and children's homes in 50 locations. As of July 1965, 21 basic institutions and eight auxiliary institutions were sampled. The selection of sampling sites was based on the coverage of different economic and social segments of the population.

In January 1966, the ITDSN was supplemented by a radiobioassay program covering 10 institutions of the ITDSN (figure 1). The objective of the radiobioassay program was to provide an assessment of environmental radiation dose from certain internally deposited radionuclides from excretion data. Certain results from this program related to cesium-137 (*2*) and tritium (*3*) have been published previously.

In a series of papers, the results of the first 3 years of the radiobioassay program are reported. This paper also deals with the details of sampling and analysis not previously reported, analytical results, and certain conclusions. Other reports deal with selected physiological constants of urine (*4*), and certain findings relating to cesium-137 (*5*) and strontium-90 (*6*).

Procedures

The details of sampling and analysis of food samples of the ITDSN have been described repeatedly in *Radiation Data and Reports*. The sampling procedure was identical at each station. Each sample consisted of an edible portion of the diet for a full 7-day week. All intake was included except drinking water, which was sampled periodically. Subsequently, food samples were frozen and mailed to appropriate laboratories for analysis.

The sampling procedure for urine was as follows: once each month, two children from each station were asked to collect a 24-hour urine sample starting with the morning voiding. One-gallon disposable polyethylene con-

---

[1] National Environmental Research Center—Las Vegas, Environmental Protection Agency, Las Vegas, Nev.

[2] Present address: Georgia Institute of Technology, Atlanta, Ga.

[3] Eastern Environmental Research Facility, Montgomery, Ala.

134

Table 1. Radiobioassay results, food and urine, ITDSN, Wilmington, Del., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
71	12	M	Jan	[b] 0.280	6.7	1.016		705	33	23	36	35	70	21	3	1.8	27	11	22	16
72	12	M		.825	5.7	1.030		875	47	41	13	35	70	21	4	3.6	72	11	22	16
88	12	M	Feb	.800	6.6	1.026		740	46	34	12	40	70	24	4	2.7	39	10	18	13
89	10	M		.760	6.6	1.025		1,120	37	42	16	40	70	24	7	7.4	[b] 148	10	18	13
105	12	M	Mar	.860	6.4	1.023		780	68	53	18	40	85	24	3	2.5	36	11	24	16
106	9	M		.914	5.7	1.027		700	60	42	19	40	85	24	6	4.5	32	11	24	16
142	12	M	Apr	.947	5.9	1.024		740	41	30	27	25	55	16	3	2.0	18	9	19	15
143	12	M		.717	6.1	1.018		1,120	43	48	21	25	55	16	2	2.2	37	9	19	15
171	12	M	May	.860	6.1	1.025		660	62	41	20	25	50	17	3	2.0	22	10	20	14
172	10	M		.759	6.3	1.026		940	49	46	16	25	50	17	5	4.9	41	10	20	14
211	11	M	June	.885	6.5	1.018		1,140	22	25	13	25	50	15	5	5.4	42	11	22	16
212	12	M		1.000	5.8	1.017		1,200	13	16	12	25	50	15	4	4.9	26	11	22	16
235	12	M	July	1.020	5.6	1.026		960	43	41	21		58		5	4.5	45			
236	11	M		1.000	5.6	1.027		830	57	47	18		58		2	1.3	11			
254	10	M	Aug	.770	6.0	1.020		800	35	28	10	25	50	15	5	4.3	43	10	20	14
255	12	M		1.460	6.2	1.022		1,280	48	61	19	25	50	15	3	4.2	22	10	20	14
283	10	M	Sept	.902	6.4	1.020		960	25	24	9	25	50	14	5	4.7	28	10	20	14
284	12	M	Oct	1.095	6.6	1.023		830	37	31	9	25	55	15	5	3.9	43	10	21	16
349	10	M	Nov			1.015		1,040	26	27	14	25	50	15				11	21	14
350	11	M	Dec			1.020		1,020	22	22	8	25	50	17				8	16	11
1967																				
384	12	M	Jan	1.09	5.0	1.016		1,580	11	17	6	15	35	9	3	5.1	23	10	22	15
385	11	M		1.50	5.0	1.022		1,580	23	36	9	15	35	9	2	3.3	15	10	22	15
394	12	M	Feb	.83	5.6	1.016		1,220	18	22	7	25	55	14	1	1.0	7	9	20	13
395	11	M		1.25	5.4	1.024		1,560	23	36	11	25	55	14	1	1.8	9	9	20	13
411	11	M	Mar	1.10	5.2	1.020		1,100	37	41	18	20	40	10	1	1.2	7	10	21	15
412	12	M		.76	4.5	1.015		1,180	16	19	12	20	40	10	2	1.9	17	10	21	15
463	12	M	Apr	.87	5.5	1.015	515	1,180	<10	< 7		10	20	5	2	1.8	18	9	20	13
464	12	M		1.44	6.0	1.020	631	1,640	14	23	6	10	20	5	3	4.3	16	9	20	13
475	11	M	May	.47	6.3	1.010	318	1,300	25	33	17	15	30	8	2	2.2	33	8	17	11
476	12	M		1.53	6.0	1.025	910	1,500	47	71	15	15	30	8	4	5.6	16	8	17	11
507	11	M	June	.57	5.8	1.010	423	1,420	21	30	17	30	70	18	2	3.5	29	12	28	15
508	12	M		.61	6.1	1.018	790	800	32	26	19	30	70	18	5	3.6	33	12	28	15
509	12	M	July	1.37	5.8	1.015	594	1,820	15	27	14	17	40	9	2	3.8	6	16	14	7
510	11	M		.47	6.5	1.005	275	1,340	<10	<11		17	40	9	2	2.2	25	16	14	7
531	11	M	Aug	[a] 2.28	5.7	1.010	527	1,520	39	59	28	14	31	8	2	2.7	20	9	20	13
532	12	M		[a] 2.25	5.9	1.011	456	2,082	26	54	18	14	31	8	1	2.8	5	9	20	13
553	10	M	Sept	.65	6.3	1.015	663	1,160	27	31	10	0	0	0	[b] 14	15.7	127	10	21	14
554	11	M		.73	6.1	1.024	1,550	630	20	13	26	0	0	0	8	5.1	35	10	21	14
564	11	M	Oct	.78	6.1	1.012	535	1,030	14	14	8	0	0	0	2	1.8	20	10	21	13
583	10	M	Nov	[a] 2.76	6.9	1.013	581	1,105	10	10		12	27	8	1	1.4	8	8	18	12
584	11	M		1.43		1.025	1,200	550	16	9	9	12	27	8	3	1.7	13	8	18	12
596	11	M	Dec	.96	6.0	1.035	3,100	740	15	11	5	14	29	9	2	1.4	9	7	15	11
597	10	M		.41	6.5	1.020	468	1,020	<10	< 8		14	29	9	1	1.1	11	7	15	11

1968

602	12	M	Jan	0.75	6.3	1.012	348	1,500	12	18	16	13	26	7	2	2.4	22	10	21	14
603	11	M		1.43	5.9	1.033	1,500	700	21	15	10	13	26	7	<1	< .3		10	21	14
625	10	M	Feb	.54	6.5	1.026	936	860	33	28	12	0	0	0	3	3.0	28	8	16	12
626	11	M		.71	6.2	1.026	953	710	18	13	9	0	0	0	1	.8	8	8	16	12
633	11	M	Mar	1.03	6.1	1.030	1,855	720	22	16	20		0	0		<1.0		8	18	11
634	10	M		.76	6.6	1.033	1,550	740	<10				0	0		<1.0		8	18	11
644	9	M	Apr	.91	6.1	1.032	1,650	720	10	7	4	14	31	10		<1.0		7	15	10
645	11	M		.68	6.0	1.020	775	820	11	9	7	14	31	10		<1.0		7	15	10
663	10	M	May	.50	6.4	1.015	500	1,100	18	20	9	11	25	7		<1.0		8	18	11
664	11	M	June	.76	6.6	1.027	1,550	820	14	11	6	14	29	9		<1.0		9	18	12
672	11	M	July	.98	5.8	1.035	3,150	640	20	12.8	10	11	23	7	2	1.2	10	9	19	15
673	9	M		.49	6.6	1.016	500	620				11	23	7	<1	< .5	10	9	19	15
693	11	M	Aug	.87	5.7	1.031	2,500	400	20	8	13	14	30	8	3	1.3	27	7	15	11
694	10	M		1.32	6.0	1.026	930	600	25	15	10	14	30	8	2	1.4	18	7	15	11
710	9	M	Sept	.85	5.6	1.026	1,950	580	37											
711	10	M		[b] .37	6.5	1.013	540	810	22											
721	9	M		.79	5.8	1.026	940	420	<10	.60		0	0	0	3	1.1	14	10	20	15
722	11	M		1.08	6.0	1.023	920	730	<10	<10		0	0	0	1	.7	6	10	20	15
731	11	M	Oct	1.06	5.8	1.022	795	760	20			13	28	8	2	1.7	13	5	11	7
732	10	M		1.10	6.2	1.018	605	1,100	12			13	28	8	2	2.1	13	5	11	7
748			Nov	.80	5.7	1.017	700	560	20	11	16	0	0	0	3	1.5	34	8	17	11
749	11	M		1.59	6.6	1.019	680	1,020	<10	< 2		0	0	0	2	1.8	16	8	17	11
756	9	M	Dec	1.52	5.4	1.018	675	1,480	16	24	8	0	0	0	<1	<1.1	14	8	17	12
757	11	M		.63	6.4	1.018	555	700	<10	< 6		0	0	0	2	1.3	17	8	17	12

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

tainers were used for sample collection. During 1966, 60 ml of an alcoholic solution of merthiolate were placed in the sample collection container prior to shipment to the collection sites. Subsequently, 1 ml of an aqueous merthiolate solution replaced the alcohol solution as the preservative agent to avoid possible errors in tritium data (3). Upon arrival of the urine samples, the volume, specific gravity, and pH value of the samples were determined by conventional techniques.

Osmolality of the urine samples was determined using an osmometer manufactured by Advanced Instrument, Inc. The standard provided by the manufacturer consisted of a sodium chloride solution containing colloids resembling urine specimens.

Creatinine was analyzed using the Folin technique as modified by Clark and Thompson (7). Results from early experiments in our laboratory indicated that substantial errors were introduced if urine was improperly preserved. Therefore, special attention was given to the preservation and handling of the 24-hour urine samples. Subsequently, 1-liter aliquots of urine samples were subjected to gamma spectroscopy. If the volume of urine was less than the required 1 liter, appropriate amounts of distilled water were added.

The determination of strontium-90 in urine was carried out according to the anion exchange procedure of Cahill and Lindsey (8). Calcium analysis was performed using the classical procedure of oxalate precipitation and permanganate titration.

Results and discussion

Tables 1 to 10 show analytical results of the radiobioassay program of the ITDSN. For convenience, the diet data as previously reported (9) are also included.

A detailed discussion of the results and their significance is beyond the scope of this first paper in the series; however, a short discussion of the results may be of interest. Columns 5–9 of the tables contain physiological parameters of urine. As a control population was essentially unavailable, statistical methods were used to eliminate certain data which were suspected to be derived from incomplete sample collection.

Table 2. Radiobioassay results, food and urine, ITDSN, Tampa, Fla., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/ liter)	(pCi/ day)		(pCi/ kg)	(pCi/ day)		(pCi/ liter)	(pCi/ day)		(pCi/ kg)	(pCi/ day)	
1966																				
55	12	M	Jan	1.480	6.1	1.022		1,400	149	208	57	70	150	50	4	5.4	36	9	12	13
56	12	M		[a] 1.830	6.4	1.020		1,900	110	210	58	70	150	50	5	8.8	50	9	19	13
73	12	M	Feb	[b] .218	6.2	1.009		[b] 280	107	30	47	45	90	27	7	2.0	80	14	29	16
74	9	M		.574	6.1	1.028		700	134	94	55	45	90	27	5	3.8	40	14	29	16
107	13	F	Mar	.317	6.7	1.018		440	95	42	36	60	120	40	3	1.4	23	10	20	14
108	10	F		.490	6.4	1.020		500	130	65	40	60	120	40	7	3.5	70	10	20	14
113	12	F	Apr	.470	6.8	1.009		1,960	25	49	26	85	165	50	1	2.3	15	11	21	12
114	12	F		.[illegible]78	6.8	1.020		640	105	67	34	85	165	50	4	2.6	37	11	21	12
169	9	M	May	[b] .319	6.4	1.025		440	132	58	107	55	85	43	8	3.5	13	9	14	16
170	12	M		[b] .085	7.0	1.017		[b] 150	280	42	300	55	85	43	12	1.8	38	9	14	16
201	6	M	June	.548	5.5	1.026		600	117	70	52	80	130	50	7	4.4	36	12	20	20
202	8	M		.538	6.4	1.026		480	90	43	36	80	130	50				12	20	20
223	9	M	July	.960	5.6	1.026		800	164	131	66	55	95	37	2	1.9	11	8	14	16
224	10	M		.851	6.1	1.012		1,820	53	97	67	55	95	37	1	2.7	40	8	14	16
229	9	M	Aug	[b] .300	6.0	1.027		340	194	66	102	75	170	47	3	1.0	20	12	27	19
230	8	M		.670	6.1	1.018		800	105	84	57	75	170	47	2	1.2	33	12	27	19
276	12	M	Sept	.435	6.3	1.012		435	78	34	110	80	170	47				14	29	22
277	10	F		[b] .320	6.9	1.020		430	98	42	47	80	170	47				14	29	22
242	10	F		.670	5.8	1.017		1,300	65	84	57	80	170	47	2	3.0	16	14	29	22
243	10	F		.866	6.5	1.026		620	98	61	30	80	170	47	4	2.2	29	14	29	22
287	10	F	Oct	.519	6.3	1.024		440	77	34	23	105	235	69	7	3.0	58	10	22	16
288	10	F		.755	6.4	1.014		1,020	69	70	43	105	235	69	2	2.3	12	10	22	16
296	9	M		.666	6.8	1.022		660	176	116	53	105	235	69	5	3.0	30	10	22	16
297	8	M	Nov	[b] .360	6.6	1.020		450	131	59	59	45	95	28	4	1.6	26	10	21	19
363	10	F	Dec			1.005		980	57	56	37	50	100	27				10	20	17
364	10	F				1.016		390	82	32	31	50	100	27				10	20	17
1967																				
372	10	F	Jan	.57	5.8	1.017		880	26	23	18	35	75	20	1	1.1	8	9	20	15
373	11	F	Feb	.42	5.8	1.016		700	34	24	32	35	75	22	2	1.4	14	6	13	10
429	11	F	Mar	.94	5.5	1.011		1,180	31	37	21	40	85	21	.3	.4	15	8	17	14
430	10	F		1.22	6.0	1.022		1,020	70	71	21	40	85	21	.2	.2	2	8	17	14
471	9	M	Apr	.74	6.4	1.020	779	900	64	58	25	35	70	20	3	2.6	50	7	14	14
472	12	M		.56	6.4	1.028	1,035	600	49	29	24	35	70	20	3	2.0	75	7	14	14
479	11	F	May	.45	5.8	1.032	1,195	[b] 250	16	4	29	40	85	23	4	.9	80	8	17	17
480	9	M		.39	6.2	1.020	790	[b] 300	12	4	17	40	85	23	3	.9	150	8	17	17
497	11	F	June	.71	6.6	1.022	812	790	71	56	30	50	100	20	3	2.0	30	7	14	12
498	11	F		.76	6.1	1.026	1,500	760	49	37	21	50	100	20	[b] 9	6.6	112	7	14	12
513	12	F	July	.82	6.7	1.020	705	630	39	25	25	61	118	32	2	1.0	100	5	10	9
514	11	F		.65	6.1	1.028	2,000	540	45	24	29	61	118	32	1	.8	6	5	10	9
529	9	M	Aug	1.11	5.9	1.020	595	640	45	29	48	43	89	24	1	.3	18	7	15	12
530	10	M		1.05	6.1	1.024	609	720	40	29	33	43	89	24				7	15	12
543	12	F	Sept	.49	5.4	1.020	670	390	25	10	37	55	115	30	1	.3	50	9	19	16
544		F		.52	6.3	1.030	1,550	360	21	8	18	55	115	30	5	1.8	31	9	19	16
558	10	M	Oct	.43	6.0	1.021	704	655	34	22	63	29	61	18	1	.5	6	6	12	9
559	7	M		[b] .24	5.7	1.015	613	455	<10	<4		29	61	18	1	.3	17	6	12	9
579	9	F	Nov	1.06	6.5	1.014	522	1,760	66	116	32	44	92	24	2	3.3	20	4	9	8
580	11	F		.52	6.4	1.027	909	550	39	21	27	44	92	24	3	1.6	21	4	9	8
598	7	M	Dec	.55	6.7	1.033	1,250	790	84	66	40	54	116	29	1	.7	17	6	12	9
599	8	M		.54	6.5	1.034	824	900	84	76	62	54	116	29	1	1.1	8	6	12	9

1968																				
610		M	Jan	1.02	6.1	1.025	739	1,360	76	103	40	34	60	20	1	1.3	5	6	10	13
611	9	M		b .20	6.7	1.020	658	500	36	18	28	34	60	20				6	10	13
627	10	F	Feb	b .27	6.5	1.025	814	730	51	37	25	31	67	17	2	1.5	31	10	21	18
628	9	F		.76	6.6	1.025	809	870	61	53	25	31	67	17	3	2.4	32	10	21	18
655	11	F	Apr	b .24	5.7	1.030	2,750	b 340	15	5	18	28	62	16		<1.0		6	13	11
656	9	F		.45	5.4	1.020	655	480	21	10	29	28	62	16	2	1.1	14	6	13	11
668	8	M	May	.40	6.2	1.032	914	455	29	13	26	40	89	23	3	1.3	18	8	18	13
669	15			1.12	5.4	1.030	1,750	780	21	16	14	40	89	23		<1.0		8	18	13
680	9	M	June	.83	6.4	1.013	530	2,000	55	110	65	24	48	13	1	1.2	9	7	14	12
681	7	M		b .20	5.7	1.020	710	780	56	44	63	24	48	13	2	1.2	22	7	14	12
686	10	M	July		5.3	1.026		750	49	37	23	34	51	22	3	2.1	13	7	11	16
687	12	M		b .05	5.7	1.020	765	b 310	24	7	22	34	51	22	2	.5	66	7	11	16
701	12	M	Aug	.57	6.3	1.019	645	550				35	54	22	6	1.5	120	10	15	21
702	10	F		.42	5.3	1.032	3,200	240	12	5	23	35	54	22	1	.6	20	10	15	21
712	10	M	Sept		5.1	1.027	1,700	400	38	15	29	32	49	20	2	1.0	7	8	13	16
713	9	M		1.07	6.0	1.020		570	40	23	27	32	49	20	3	1.6	25	8	13	16
733	10	M	Oct		5.2	1.031	920	b 315	28	9		38	53	23	3	1.0	12	10	14	20
734	8	F		.81	6.4	1.021	770	430	45	19		38	53	23	3	1.4	43	10	14	20
737	8	M	Nov	.95	6.6	1.031	955	700	54	38	36	37	51	20	3	1.8	27	10	13	14
738	9	M			5.6	1.030	670	b 170	<10	<1	27	37	51	20	5	0.9	21	10	13	14
752	11	M	Dec	.98	5.4	1.031	1,100	640	32	20	32	24	32	19	3	1.7	11	6	8	16
753	8	M		b .29	5.2	1.027	995	b 150	13	2	40	24	32	19	3		11	6	8	16

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

These values are marked in the tables. Values outside the normal range are also marked. However, the high values were included in the evaluation of the data. Some calcium and strontium values were statistically invalid, although values were observed. In other cases, the value of strontium was unreasonably high while the value of calcium was unreasonably low. In these cases, the values were omitted from the strontium-calcium observed ratio analysis. An evaluation of the physiological constants of urine (*4*) reveals that creatinine in combination with volume may be used to validate a 24-hour urine sample. The calculated average body burden of children for cesium-137 was 3.8 nCi for 1966 and 1.7 nCi for the subsequent years (*5*). The location with the highest value was Tampa, Fla., with values of 7.0, 4.3, and 2.6 nCi for the 1966 to 1968 period. The strontium-90 values expressed in terms of observed ratio (urine/diet, pCi ^{90}Sr/g Ca) was 2.3 for 1966, 2.2 for 1967, and 1.8 for 1968, with an average of 2.0 for the entire period (*6*).

The estimated annual dose for the entire period for cesium-137 (*5*) averaged 1.1 mrem with muscle as the critical organ and 8.9 mrad for strontium-90 (*6*) with bone as the critical organ.

REFERENCES

(*1*) ANDERSON, E. C. and D. J. NELSON, Jr. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391 (1962).

(*2*) CAHILL, D. F. and J. K. WHEELER. The biological half-life cesium-137 in children determined by urinary assay. Health Phys 14:293 (1968).

(*3*) MOGHISSI, A. A. and R. LIEBERMAN. Tritium body burdens of children, 1967–1968. Radiol Health Data Rep 11:227–231 (May 1970).

(*4*) MOGHISSI, A. A. and M. G. MAYES. Radiobioassay program of the Institutional Total Diet Sampling Network: II. Selected physiological constants of urine. Radiat Data Rep 14: (1973) (in press).

(*5*) MOGHISSI, A. A. and M. G. MAYES. Radiobioassay program of the Institutional Total Diet Sampling Network: III. Cesium-137 dose estimates and body burdens of children. Radiat Data Rep 14: (1973) (in press).

Table 3. Radiobioassay results, food and urine, ITDSN, Idaho Falls, Idaho, 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Crea-tinine (g/day)	pH	Specific gravity	Osmola-lity (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
67	17	M	Jan	0.680	6.5	1.027		410	100	41	30	45	85	34	2	0.7	10	9	7	11
68	17	M		[a]1.700	5.6	1.026		1,060	56	59	24	45	85	34	3	3.1	29	9	17	11
79	16	M	Feb	.820	6.5	1.026		460	72	33	20	35	65	24	3	1.3	17	16	29	19
80	16	M		1.270	5.8	1.033		610	74	45	32	35	65	24	.5	.3	4	16	29	19
94	15	M	Mar	1.080	5.9	1.018		1,320	37	49	25	40	75	28	6	7.6	149	11	21	16
115	15	M	Apr	.583	6.3	1.019		620	34	21	18	30	55	20	3	1.6	24	8	14	12
119	17	M		.583	6.4	1.028		360	44	16	21	30	55	20	4	1.5	19	8	14	12
167	16	M	May	1.290	6.1	1.023		770	64	49	24	30	55	20	3	2.0	22	25	43	19
168	17	M		1.329	6.0	1.029		510	78	40	22	30	55	20	4	2.0	27	25	43	19
193	17	M	June	1.600	6.6	1.028		1,050	57	60	27	30	45	21				6	9	9
194	17	M		1.530	6.4	1.028		1,000	66	66	25	30	45	21				6	9	9
225	16	M	July	1.391	5.4	1.028		940	34	32	16	25	40	16	4	3.7	20	6	10	5
226	17	M		.938	6.4	1.027		920	34	31	19	25	40	16	4	3.3	16	6	10	5
239	16	M	Aug	1.390	5.9	1.023		770	38	29	17	35	80	25	2	1.2	29	9	21	12
258	16	M	Sept	1.600	5.9	1.020		1,380	42	58	17	30	70	17	2	3.0	23	9	21	11
259	17	M	Oct	.830	5.8	1.027		600	38	23	18	30	60	17	[b]29	17.4	120	12	24	12
292	16	M	Nov	[a]1.952	6.4	1.026		1,220	48	58	14	30	65	17	1	1.8	11	9	20	10
308	16	M	Dec	[a]1.740	6.4	1.022		1,280	40	51	12	20	45	12	8	10.0	46	13	29	15
1967																				
380	17	M	Jan	0.91	6.0	1.030		660	40	26	14	30	65	17	2	1.1	14	11	24	11
381	18	M		1.56	4.8	1.030		920	49	45	17	30	65	17	3	2.3	43	11	24	11
386	16	M	Feb									25	45	13				11	19	16
387	17	M							41			25	45	13				11	19	16
435	17	M	Mar	1.30	6.8	1.020		1,080	28	30	9	10	20	5	1	1.3	14	8	17	9
436	18	M		1.53	6.2	1.023		900	36	32	12	10	20	5	1	1.1	7	8	17	9
469	17	M	Apr	[a]1.86	6.5	1.025	1,005	1,500	33	50	11	10	20	5	18	27.6	120	8	17	10
470	17	M		1.64	6.4	1.025	875	1,300	26	34	13	10	20	5	11	14.2	58	8	17	10
485	17	M	May	1.30	5.0	1.025	1,044	940	<10	7		20	35	11	2	1.8	13	7	13	5
486		M		1.04	5.4	1.030	1,203	700	14	10	6	20	35	11	1	1.0	20	7	13	5
511	17	M	June	[a]1.80	6.3	1.020	864	1,640	38	62	17	15	25	9	3	4.8	18	2	1	1
512	16	M		1.11	6.6	1.025	927	1,060	16	17	6	15	25	9				2	1	1
525	16	M	July	[a]2.11	5.7	1.021	726	1,200	30	36	15	12	22	7	1	1.5	8	6	11	4
526	17	M		[a]2.33	5.5	1.016	884	800	29	23	12	12	22	7	2	1.6	18	6	11	4
541	15	M	Aug	[a]3.69	5.3	1.025	938	1,500	16	24	5	26	53	13	1	1.9	5	14	30	12
542	15	M		[a]3.13	6.1	1.029	979	1,150	38	44	13	26	53	13	1	.8	7	14	30	12
555	13	M	Sept	1.22	5.0	1.006	275	3,400	13	44	19	0	0	0	1	3.8	33	9	16	6
567	13	M		1.52	6.4	1.010	372	2,310	<10	12		0	0	0	2	3.5	20	9	16	6
568	13	M	Oct	1.39	6.2	1.012	317	2,680	15	40	12	16	31	9	2	5.4	20	7	13	7
581	15	M		1.25	5.6	1.018	696	1,100	20	22	7	16	31	9	.2	.2	1	7	13	7
582	15	M	Nov	[a]1.75	5.5	1.031	1,600	700	37	26	9	14	30	8	1	.7	33	7	15	7
585	14	M		[b].37	5.6	1.011	453	1,840	16	29	9	14	30	8	3	5.0	43	7	15	7
586	14	M	Dec	[a]2.75	6.1	1.011	328	2,220	16	36	11	13	28	8	2	4.0	100	7	16	6

1968

612	13	M	Jan	.83	6.3	1.020	711	960	35	34	25	12	27	7	2	1.9	31	13	30	10
613	13	M		.62	6.3	1.020	796	660	13	9	8	12	27	7	1	.7	19	13	30	10
617	15	M	Feb	[a]2.11	5.5	1.035	2,500	1,120	38	43	10	0	0	0	1	.6	2	7	16	7
618	15	M		[a]1.71	6.2	1.031	900	1,300	22	29	9	0	0	0	3	4.2	17	7	16	7
640	15	M	Mar	.87	7.1	1.030	976	760				18	34	13		<1.0		10	18	11
641	15	M		[a]1.64	6.0	1.030	3,300	980				18	34	13		<1.0		10	18	11
653	16	M	Apr	[a]1.64	5.1	1.023	832	1,220	<10	<5		13	28	9	2	3.0	10	12	26	9
654	16	M		[a]2.19	5.5	1.030	1,600	1,080	22	24	5	13	28	9		<1.0		12	26	9
659	16	M	May	[a]2.13	6.0	1.025	778	1,600	27	43	9	13	27	8	1	1.6	5	8	15	10
660	16	M		[a]2.36	6.0	1.027	854	1,560	27	41	9	13	27	8		<1.0		8	15	10
676	17	M	June	1.22	5.9	1.013	455	2,580				19	40	12	1	2.8	11	8	18	10
677	17	M		.60	6.1	1.012	260	1,390				19	40	12	1	1.7	17	8	18	10
697	17	M	July	1.07	8.3	1.020	910	1,340	27	36	13	20	44	15	<1	.1		7	16	7
698	17	M		1.35	8.1	1.016	860	1,500	41	62	19	20	44	15	<1	2.4		7	16	7
714	16	M	Sept	[a]1.71	6.3	1.020	820	1,840	33	61	8	13	23	8	2	4.1	12	10	18	8
715	16	M		[a]2.26	6.0	1.016	640	1,760	28	49	9	13	23	8	3	4.7	10	10	18	8
727			Oct	.60	5.9	1.015	515	580	11	6	12	16	29	10	2	1.0	18	9	16	6
728				[b].20	6.5	1.013	525	[b]155				16	29	10				9	16	6
739	14	M	Nov	[a]2.15	6.2	1.022	760	1,600	29	46	10	25	53	14	2	2.4	40	11	23	10
740	14	M		1.51	6.5	1.030	1,500	1,000	42	42	12	25	53	14	<1	> .1		11	23	10
754	17	M	Dec	[a]2.14	5.9	1.019	555	2,000	11	22	8	23	46	13	2	4.0	17	8	16	6
755	17	M		[a]2.28	5.6	1.012	500	2,350	18	42	14	23	46	13	1	3.3	8	8	16	6

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

Table 4. Radiobioassay results, food and urine, ITDSN, Chicago, Ill., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
59	12	F	Jan	0.750	6.0	1.019		800	53	42	16	45	75	29	5	[b]3.6	73	7	12	9
60	13	F		.645	5.9	1.018		660	42	28	20	45	75	29	6	[b]3.8	78	7	12	9
75	11	M	Feb	.640	6.5	1.019		460	43	20	18	45	65	33	4	1.7	36	9	13	13
76	11	M		.740	6.5	1.017		440	68	30	22	45	65	33	2	1.0	29	9	13	13
92	13	F	Mar	1.100	5.6	1.028		660	86	57	26	40	70	28	8	[b]5.6	98	9	15	11
93	13	F		.830	6.1	1.022		740	54	40	16	40	70	28	6	[b]4.5	129	9	15	11
134	12	M	Apr	.713	6.6	1.027		810	33	27	24	35	50	25	3	2.3	35	8	11	11
128	12	M		.622	6.2	1.017		740	32	24	22	35	50	25	2	1.8	49	8	11	11
163	13	F	May	.860	6.0	1.017		1,240	46	57	31	40	60	27				8	12	11
164	13	F		1.254	6.4	1.017		1,340	42	56	21	40	60	27	3	3.6	33	8	12	11
187	13	F	June	1.496	6.2	1.029		730	68	50	27	30	50	22	3	2.0	15	12	20	18
188	12	F		.810	6.2	1.019		860	44	38	51	30	50	22	2	1.8	19	12	20	18
220	12	M	July	.828	5.8	1.023		600	28	17	11	20	30	15	4	2.2	19	6	9	9
221	12	M		.932	5.9	1.019		1,000	26	26	11	20	30	15	2	2.2	30	6	9	9
232	12	M	Aug	.895	6.1	1.025		710	83	59	34	15	20	10	4	2.7	33	6	8	8
233	12	M		.170	5.6	1.017		[b]180	94	17	31	15	20	10	5	.9	11	6	8	8
252	13	F	Sept	.800	5.7	1.017		740	36	27	18	20	35	13	4	2.6	25	6	10	8
253	11	F		.770	5.9	1.024		520	37	19	13	20	35	13				6	10	8
294	12	M	Oct	.924		1.018		670	30	20	14	25	40	19	4	2.9	24	7	11	12
295	12	M		[b].370		1.022		[b]290	38	11	12	25	40	19	8	2.3	15	7	11	12
333	13	F	Nov			1.020		1,120	45	50	30	25	45	15				7	12	10
334	11	F				1.019		820	59	48	20	25	45	15				7	12	10
367	12	M	Dec			1.023		520	42	22	13	25	30	16				8	9	11
368	12	M				1.028		360	44	16	16	25	30	16				8	9	11

Table 4. Radiobioassay results, food and urine, ITDSN, Chicago, Ill., 1966–1968—continued

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
											1967									
376	11	F	Jan	.92	5.4	1.016		1,080	29	31	19	15	25	10	1	.7	11	7	11	10
377	11	F		.88	5.7	1.023		820	26	21	11	15	25	10	1	1.1	20	7	11	10
398	12	M	Feb	.76	4.6	1.028		820	28	19	9	20	30	12	2	1.4	22	7	11	9
433	12	F	Mar	1.02	6.3	1.020		1,080	22	24	11	20	35	11	2	1.7	22	7	12	9
434	11	F		.77	6.2	1.023		820	37	30	15	20	35	11	1	.9	20	7	12	9
461	12	M	Apr	.76	5.5	1.021	839	880	17	15	7	10	15	6	1	.7	20	7	11	11
462	12	M		.67	5.6	1.025	935	500	16	8	20	10	15	6	2	.9	13	7	11	11
483	11	F	May	1.04	6.6	1.020	699	1,160	30	35	12	15	30	10	1	.9	33	8	16	10
484	12	F		1.06	6.2	1.025	846	1,520	15	23	8	15	30	10	2	2.9	17	8	16	10
499	12	F	June	.85	6.4	1.025	914	820	20	16	8	15	25	10	1	.9	20	8	13	12
500	11	F		1.34	5.8	1.020	844	1,340	20	27	12	15	25	10	1	1.7	11	8	13	12
517	12	M	July	.73	6.0	1.016	615	780	13	10	14	22	29	13	1	1.1	10	7	9	10
518	11	M		.73	5.8	1.020	800	960	18	17	13	22	29	13	1	1.1	17	7	9	10
527	12	F	Aug	[a]2.78	5.6	1.030	1,150	960	37	36	17	18	30	12	1	.8	10	8	13	11
528	12	F		.94	5.9	1.022	673	440	13	6	15	18	30	12	2	.9	100	8	13	11
556	12	F	Oct	1.02	5.3	1.024	968	850	33	28	22	11	18	7	1	.9	8	5	6	7
557	12	F		.83	5.6	1.024	781	755	24	18	20	11	18	7	1	.8	25	5	6	7
577		M	Nov	1.01	5.8	1.018	747	1,260	18	23	10	15	20	8	2	2.1	11	7	12	9
578		M		1.32	6.2	1.016	724	1,160	13	15	8	15	20	8	6	6.4	46	7	12	9
593	13	F	Dec	.90	6.2	1.020	791	1,000	14	14	6	24	35	14	3	2.8	150	7	10	10
594	12	F		1.26	6.5	1.021	796	1,000				24	35	14	1	.7	25	7	10	10
											1968									
606	10	M	Jan	1.20	5.8	1.025	911	920	29	27	13	18	29	11	3	2.4	52	6	10	8
607	11	M		.86	5.8	1.025	810	540	33	18	25	18	29	11	3	1.4	19	6	10	8
621	13	F	Feb	.97	5.7	1.027	926	480	18	9	16	15	23	10	4	2.1	27	7	10	9
622	13	F		1.53	5.8	1.029	1,600	880	22	19	9	15	23	10	6	5.5	36	7	10	9
635	12	M	Mar	.44	5.9	1.017	540	560				22	34	12		<1.0		6	9	6
636	11	M		.65	6.0	1.020	768	540	15	8	29	22	34	12		<1.0		6	9	6
651	12	F	Apr	1.31	6.1	1.020	738	1,190	<10	11		15	19	9		<1.0		7	9	9
652	12	F		1.11	6.3	1.022	770	800	<10	7		15	19	9		<1.0		7	9	9
661	12	M	May	.87	5.0	1.022	755	800	14	11	8	14	22	10	2	1.2	17	6	10	9
662	11	M	June	.89	6.2	1.035	1,500	420								<1.0				
699	15	F	July	.99	6.0	1.032	1,500	650				12	17	8	3	2.1	18	7	10	13
700	15	F	Aug	1.29	5.5	1.034	3,100	620		11	10				2	1.0	11	NS		

[a] Values outside of the normal range, but included in evaluation.   [b] Values outside of the normal range, and excluded from further evaluation.   NS, no sample.

Table 5. Radiobioassay results, food and urine, ITDSN, Louisville, Ky., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
63	11	M	Jan	0.433	5.2	1.020		460	24	11	9	25	35	14	7	3.0	61	12	16	15
64	11	M		.695	5.3	1.025		420	80	34	21	25	35	14	6	2.5	60	12	16	15
84	11	M	Feb	.740	5.8	1.023		710	39	28	16	25	35	17	5	3.8	21	16	22	16
85	12	M		.855	5.7	1.028		610	49	30	16	25	35	17	7	4.2	62	16	22	16
198	10	M	June	.503	6.1	1.017		730	34	25	22	30	40	17	3	2.0	11	19	25	19
199	10	M		[a].330	6.5	1.017		470	30	14	12	30	40	17	4	2.0	40	19	25	19
256	14	M	Sept	[b]2.030	5.9	1.018		1,920	30	58	15	15	25	8	1	2.3	13	13	23	18
257	14	M		1.190	5.7	1.022		780	37	29	13	15	25	8	1	1.0	20	13	23	18
289	14	M	Oct	1.220	6.5	1.016		1,300	30	39	13	15	20	10	4	4.7	50	8	12	13
290	14	M		[b]1.810	6.3	1.025		880	30	26	11	15	20	10	4	3.8	75	8	12	13
342	14	M	Nov			1.020		700	44	31	15	20	35	12				11	20	13
343	14	M				1.016		1,480	22	33	12	20	35	12				11	20	13
357	12	M	Dec			1.014		1,500	<10	3		15	30	10				10	20	13
358	12	M				1.025		720	10	7	6	15	30	10				10	20	13
1967																				
374	13	M	Jan	[a].28	4.9	1.025		[a]230	<10			20	25	11	2	.5	1	9	11	12
375	12	M		[a].30	5.4	1.023		[a]330	<10			20	25	11	2	.5	1	9	11	12
399	12	M	Feb	[a].16	5.2	1.026		[a]120				15	25	9				10	18	13
400	12	M		.44	4.6	1.016		570	<10	5	11	15	25	9	1	.8	8	10	18	13
431	13	M	Mar	.48	8.8	1.017		800	13	10	15	15	25	9	1	1.0	20	12	20	17
432	12	M		[a].29	6.4	1.025		[a]260	10	3	13	15	25	9	5	[a]13.3	33	12	20	17
465	13	M	Apr	[a].33	5.2	1.030	1,125	[a]150	11	2	50	15	25	10	27	4.2	450	11	18	14
466	12	M		[a].30	5.5	1.027	996	[a]210	<10	2	33	15	25	10	4	.8	0	11	18	14
491	13	M	May	.46	5.5	1.025	993	490	14	7	13	10	15	6	4	1.8	44	12	20	15
492	13	M		.46	5.4	1.015	574	920	<10	7	11	10	15	6	1	1.2	20	12	20	15
503			June	[a].09	6.8	1.010	440	360	14	5		15	25	8				12	21	18
504		M		[a].34	5.6	1.020	749	360	<10			15	25	8	13	4.8	325	12	21	18
515	13	M	July	1.08	5.9	1.018	735	980	23	23	14	0	0	0	2	1.6	22	8	11	10
516	10	M		.48	5.8	1.010	385	800				0	0	0	.4	.3	8	8	14	10
535	11	M	Aug	.90	5.5	1.020	573	530	23	12	5	14	24	9				9	16	13
536	10	M		[b]1.71	5.6	1.023	759	1,140	22	25	9	14	24	9	2	1.8	10	9	16	13
547	13	M	Sept	.51	5.6	1.023	888	460	15	7	25	0	0	0	2	1.0	29	7	15	14
548	10	M		.44	6.5	1.024	924	[a]340	<10	.3	1	0	0	0	1	[a].2	11	7	15	14
571	10	M	Oct	.74	5.9	1.012	476	1,060	22	23	2	12	17	7	2	1.6	33	9	12	12
572		M		.43	5.4	1.020	468	740	<10	4	6	12	17	7	2	1.5	20	9	12	12
589		M	Nov	[a].22	6.4	1.002	894	550	<10	5	10	0	0	0	1	.7	7	9	16	13
590		M	Dec	.06	5.5	1.025	717	420	<10	3	2	0	0	0	1	.3	10	9	17	15
1968																				
608	10	M	Jan	[a].28	6.2	1.024	190	460	<10	3		0	0	0	1	.4	29	8	10	10
609	11	M		.34	6.2	1.011	754	480	11	5	17	0	0	0	1	.7	7	8	10	10
623	9	M	Feb	.61	6.3	1.025	901	580	<10	3		14	24	9	3	1.6	55	7	12	9
624	9	M		.45	6.4	1.028	942	440	13	6	14	14	24	9	2	.7	13	7	12	9
637			Mar	[a].37	6.1	1.018	262	580				0	0	0		<1.0		7	10	13
646			Apr	[a].22	5.5	1.031	960	[a]155				0	0	0				9	10	17
665	11	M	May	[a].28	6.1	1.030	2,300	[a]220		1		0	0	0		<1.0		8	8	20
678	11	M	June	[a].24	6.2	1.013	525	320				0	0	0	4	1.2	80	13	7	35
679	11	M		.51	5.1	1.035	1,600	460				0	0	0	3	1.4	25	13	7	35
690		M	July	.91	5.9	1.021	765	1,280	35	45	13	0	0	0	3	3.6	20	9	14	18
709	11	M	Aug	.62	6.6	1.019	670	1,200				0	0	0	2	2.8	25	6	9	10
720	12	M	Sept	1.17	5.1	1.022	815	850				0	0	0	2	1.9	10	11	19	17
735	11	M	Oct	1.40	6.2	1.026	805	720				0	0	0	2	1.3	25	9	14	13
745	11	M	Nov	.82	5.9	1.016	765	1,060	21	22	22	0	0	0	3	3.1	17	8	12	11
758	11	M	Dec	.63	5.7	1.031	1,310	460	13	6	12	11	22	7	3	1.3	14	12	24	17

[a] Values outside of the normal range, and excluded from further evaluation.

[b] Values outside of the normal range, but included in evaluation.

Table 6. Radiobioassay results, food and urine, ITDSN, Columbia, Miss., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
61	15	M	Jan	1.100	6.3	1.015		700	77	54	37				6	4	55			
62	16	M		1.490	5.3	1.015		1,960	38	72	24				3	6	48			
86	16	M	Feb	.730	6.0	1.022		570	67	38	17				8	5	73			
87	17	M		.710	6.3	1.009		1,420	41	58	19				4	6				
109	15	M	Mar	1.450	6.2	1.018		1,580	46	73	25				3	5	70			
110	16	M		1.185	6.3	1.013		1,520	45	68	43				2	3	17			
130	15	M	Apr	.673	7.1	1.020		580	76	44	27				4	2	50			
131	17	M		1.190	5.8	1.019		1,140	38	43	27				2	2	26			
165	16	M	May	[a]1.865	6.0	1.018		1,600	64	102	43				4	6	19			
166	17	M		1.065	5.8	1.018		660	77	51	44				5	3	59			
195	15	M	June	1.440	5.6	1.015		1,940	<10	<17										
196	16	M		1.430	5.9	1.026		840	39	33	27				7	6	33			
219	15	M	July	[a]1.760	5.7	1.030		740	72	53	21				9	7	36			
223	15	M		1.250	5.2	1.025		720	49	35	23				5	4	16			
231	15	M	Aug	.360	6.4	1.010		620	29	18	13				3	2	95			
234	17	M		.986	5.3	1.017		880	51	45	26				3	3	34			
249	17	M	Sept	1.020	5.4	1.013		1,080	22	24	18				3	3	41			
251	17	M		1.510	5.9	1.017		1,820	31	56	24				2	4	20			
291	17	M	Oct		6.2	1.016		1,600	27	43	16				4	6	49			
293	16	M		1.376	6.5	1.027		660	47	31	11				6	4	43			
344	17	M	Nov			1.014		1,500	45	67	36									
345	17	M				1.025		720	61	44	46									
365	16	M	Dec			1.025		1,320	25	33	15									
366	14	M				1.015		700	<10											
1967																				
378	17	M	Jan	.80	5.5	1.019		680	30	20	20				2	1.2	8			
379	16	M		1.17	5.3	1.018		900	21	19	17				2	1.4	14			
405	15	M	Fe	[a]1.75	5.1	1.026		1,180	45	53	19				10	11.5	62			
406	17	M		.88	4.9	1,030		420	32	13	45				4	1.7	16			
425	16	M	Mar	.77	5.6	1,025		1,340	30	40	13				2	2.8	15			
428	15	M		.94	5.5	1.025		900	20	18	12				2	2.0	17			
467	17	M	Apr	[a]2.92	5.5	1.025	934	1,760	26	46	13				1	2.5	5			
468	17	M		[a]2.03	5.5	1.021	832	1,720	24	41	11				2	3.8	11			
481	17	M	May	1.16	5.9	1.015	616	1,420	21	30	10				1	2.0	17			
482	14	M		1.14	5.6	1.025	974	720	19	14	12				3	2.1	23			
501	17	M	June	[a]1.92	5.4	1.025	1,500	800	33	26	13				3	2.6	18			
502	16	M		1.61	5.1	1.028	948	1,120	27	30	20				3	3.3	20			
519	17	M	July	.88	5.6	1.015	554	760	21	16	11				.3	.2	3			
520	17	M		1.23	5.9	1.018	681	770	22	17	15									
537	16	M	Aug	[a]1.71	5.9	1.020	691	1,037	29	30	11				.3	.3	18			
538	15	M		[a]2.13	5.4	1.015	533	1,060	24	25	12									
545	15	M	Sept	1.00	5.7	1.010	271	1,520	<10	< 5					2	2.3	67			
546	14	M		.66	5.7	1.027	1,800	660	33	22	20									
560	17	M	Oct	.65	5.7	1.015	455	680	<10	< 4					1	.8	7			
561	17	M		1.42	5.7	1.025	996	710	25	18	17				2	1.2	15			
573			Nov	.82	5.4	1.020	494	1,240	21	26	20				2	2.9	15			
574				[b].32	5.1	1.014	564	[b]280	<10	< 1					5	1.3	280			
591	18	M	Dec	[a]2.00	5.2	1,020	650	2,000	19	38	19				4	7.0	21			
592	17	M		1.34	5.5	1.015	566	1,260	10	13	9				3	3.9	33			

											1968									
600	17	M	Jan	0.92	6.2	1.032	824	840	27	23	12	20	35	12	4	3.4	17	12	21	15
601	16	M		.86	6.0	1.024	498	1,165	29	34	21	20	35	12	2	1.8	18	12	21	15
619	14	M	Feb	1.45	5.6	1.027	1,000	1,240	23	29	8	12	26	7	3	4.3	23	12	26	12
620	16	M		.94	6.2	1.013	464	1,460	24	35	11	12	26	7	1	1.6	9	12	26	12
638	15	M	Mar	[a] 1.65	5.2	1.030	1,650	780				15	29	10		<1.0		10	19	10
639	17	M		1.43	6.0	1.023	909	860				15	29	10	2	1.8	9	10	19	10
649	16	M	Apr	.77	6.3	1.022	571	840	10	8	5	0	0	0	1	1.2	11	13	34	14
650	17	M		[b] .08	5.9	1.010	386	460				0	0	0		<1.0		13	34	14
666	17	M	May	[a] 2.01	6.2	1.016	495	1,760				19	40	13	1	1.3	10	11	22	13
667	17	M		[a] 1.97	5.3	1.030	2,550	740	17			19	40	13	2	1.8	47	11	22	13
684	16	M	June	1.23	6.7	1.016	570	710				13	22	9	.7	.5	7	16	28	23
685	16	M		1.32	5.6	1.026	1,100	580	27	16	20	13	22	9	<1	<.2		16	28	23
688	17	M	July	1.55	5.3	1.033	2,900	800	20	16	10	16	42	11	6	4.6	30	12	32	17
689		M		1.34	6.7	1.017	680	1,960	14	27	5	16	42	11	2	3.3	17	12	32	17
705	16	M	Aug	.87	5.7	1.030	1,950	440				14	33	8	4	1.7	11	12	28	13
706	17	M		.89	5.5	1.020	630	740				14	33	8	2	1.5	10	12	28	13
718	16	M	Sept		5.0	1.020	720	1,100	17	19	12	13	23	8	3	2.9	16	11	19	15
719	17	M			5.6	1.035	2,750	700	28	20	11	13	23	8	3	2.3	21	11	19	15
736	16	M	Oct	.69	5.5	1.015	500	425	24	10	29	16	34	11	1	.6	11	11	23	14
743	17	M	Nov	1.03	6.6	1.010	505	800	37	30	25	0	0	0	5	3.7	41	9	17	11
744	16	M		[a] 1.72	7.0	1.030	1,350	900	23	21	6	0	0	0	6	5.5	27	9	17	11
759	16	M	Dec	[a] 2.34	5.1	1.022	885	1,500	22	33	9	14	33	9	2	2.5	13	9	21	9
760	16	M		.79	6.3	1.016	515	1,000	15	15	9	14	33	9	1	.9	20	9	21	9

[a] Values outside of the normal range, but included in evaluation.
[b] Values outside of the normal range, and excluded from further evaluation.

Table 7. Radiobioassay results, food and urine, ITDSN, Portland, Oreg., 1966–1968

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
69	16	M	Jan	1.450	5.8	1.020		1,340	47	63	19	50	85	33	3	3.4	28	10	17	14
70	16	M		[a]1.900	6.0	1.024		980	51	50	14	50	85	33	5	4.9	26	10	17	14
90	17	M	Feb	1.190	6.2	1.012		1,565	33	52	28	70	105	44	4	5.7	57	17	26	22
91	16	M		1.270	6.4	1.013		1,380	57	79	31	70	105	44	5	6.4	49	17	26	22
96	17	M	Mar	[a]1.850	6.3	1.024		740	112	83	32	40	50	28	4	2.9	32	12	16	18
97	15	M		[a]2.390	6.9	1.021		1,660	74	123	27	40	50	28	3	5.6	165	12	16	18
116	16	M	Apr	.940	5.6	1.022		720	40	29	25	65	95	41	4	3.0	43	20	29	26
117	15	M		1.128	6.5	1.021		1,200	19	23	10	65	95	41	2	2.7	16	20	29	26
156	15	M	May	.864	9.8	1.018		1,600	20	32	14	40	60	23	.4	.6	6	18	27	23
157	15	M		1.190	8.0	1.020		1,300	47	61	30	40	60	23	2	2.9	22	18	27	23
179	16	M	June	1.016	6.5	1.024		520	75	39	41	50	80	3.5	4	2.1		29	45	35
180	16	M		.902	6.3	1.015		1,540	42	64	41	50	80	3.5	2	2.6		29	45	35
213	16	M	July	[a]1.670	6.6	1.020		1,440	44	63	19	40	65	26	2	2.7	33	15	25	19
214	15	M		.843	5.6	1.022		740	39	29	11	40	65	26	5	4.0	22	15	25	19
237	15	M	Aug	[a]2.220	5.8	1.022		1,520	56	85	23				2	2.4	39			
238	15	M		[a]2.080	6.0	1.017		1,600	32	51	17				2	2.6	24			
246	17	M	Sept	1.440	6.5	1.020		1,820	23	42	14	40	70	27	3	5.1	22	15	26	19
247	16	M	Oct	[a]2.000	5.8	1.022		980	62	61	21	5	10	5	3	3.1	14	18	33	15
279	15	M	Nov	1.430	6.5	1.017		1,080	42	45	23	45	85	31	5	5.6	2	16	31	13
280	15	M	Dec	1.040	6.8	1.007		1,920	26	50	17	40	55	21				7	10	11
1967																				
369	16	M	Jan	.54	5.8	1.005		1,080	29	31	28	45	85	34	1	.7	25	8	16	11
388	13	M	Feb						28			20	35	17				10	17	12
389	14	M							50			20	35	17				10	17	12
423	14	M	Mar	[a]1.74	6.3	1.016		1,300	23	30	16	10	15	5	2	2.6	50	6	10	10
424	16	M		1.29	6.6	1.027		570	33	19	17	10	15	5	4	2.2	43	6	10	10
457	15	M	Apr	.98	6.3	1.005	282	2,120	35	74	27	15	25	8	1	1.5	11	8	13	12
458	15	M		[b].37	5.0	1.004	210	1,840	<10	< 2		15	25	8	.5	.9	17	8	13	12
477	15	M	May	.80	5.1	1.025	953	600	16	10	11	35	65	20	3	1.6	33	11	21	19
478	15	M		[b].19	6.5	1.007	266	720	14	10	20	35	65	20	2	1.3	33	11	21	19
493	12	M	June	.99	5.9	1.015	578	1,300	43	56	22	30	55	19	3	3.9	15	7	13	12
494	14	M		1.85	6.1	1.016	669	1,380	52	72	25	30	55	19	3	3.8	50	7	13	12
521	17	M	July	1.43	6.5	1.003	170	3,580	18	64	20	18	34	10	1	5.1	50			
522	15	M		[a]1.89	5.7	1.005	288	2,100	14	29	12	18	34	10	2	3.6	40			
533	14	M	Aug	[a]2.70	6.5	1.010	438	2,250	22	50	10	0	0	0	1	2.1	50	7	15	8
534	15	M		[a]2.86	6.2	1.015	683	1,680	19	32	12	0	0	0	1	1.7	25	7	15	8
551	14	M	Sept	1.06	6.2	1.015	562	880	<10	< 8		20	28	11	1	.6	8	6	12	12
552	15	M		[a]1.67	6.3	1.009	246	2,252	11	25	9	20	28	11	1	1.5	13	6	12	12
565	16	M	Oct	[a]2.34	5.7	1.023	871	960	30	29	13	20	45	16	2	1.9	13	5	12	11
566	15	M		1.11	5.9	1.025	990	415	12	< 5	10	20	45	16	6	2.3	43	5	12	11
575	15	M	Nov	.84	6.6	1.011	273	1,680	15	25	11	12	25	8	1	1.7	33	6	14	14
576		M		1.58	6.6	1.013	534	1,440	30	43	11	12	25	8	1	1.3	7	6	14	14
587	16	M	Dec	[a]2.23	6.7	1.004	106	2,155	<10	<17		22	39	11	.3	.6	10	4	6	4
588	17	M		[a]2.63	6.7	1.002	130	4,400	<10	< 4		22	39	11	1	3.7	33	4	6	4

1968

604	16	M	Jan	[a] 2.81	6.3	1.025	929	1,080	113	122	43	11	27	6	2	2.2	18	9	23	14
605	14	M		[a] 4.51	6.4	1.010	210	3,888	<10	<31		11	27	6	1	2.6	19	9	23	14
616	16	M	Feb	.88	6.4	1.014	315	1,540	27	42	23	23	54	9	1	1.0	1	5	13	14
631	16	M	Mar	1.28	6.6	1.023	871	700				35	85	18		<1.0		5	13	11
632	16	M		[b] .15	6.5	1.005	110	940				35	85	18		<1.0		5	13	11
647	17	M	Apr	[a] 1.85	6.4	1.020	487	1,860	15	28	10	20	44	12		<1.0		6	13	10
648	17	M		[a] 1.98	6.2	1.014	506	2,135	<10	< 9		20	44	12	1	1.1	3	6	13	10
657	15	M	May	.85	5.7	1.014	395	1,120	13	15	8	14	33	9	2	1.8	16			
658	18	M		[a] 1.70	6.1	1.010	303	2,900	12	35	13	14	33	9	1	1.9	8			
682	15	M	June	.38	5.7	1.012	375	1,580				23	53	14	1	1.0	25	6	14	10
683	14	M			9.7	1.020	915	1,160	25	29	7	23	53	14				6	14	10
691	16	M	July	[a] 1.67	6.5	1.010	330	3,069	18	55	15				1	1.8	20			
692	15	M		[a] 1.62	6.1	1.011	420	1,920	24	46	15				2	3.1	18			
707	17	M	Aug	.55	5.8	1.017	565	410				0	0	0	2	1.5	29	7	15	14
708		M		1.61	5.8	1.025	885	730				0	0	0	1	.8	33	7	15	14
716	17	M	Sept	1.41	5.8	1.015	575	1,300	33	43	12	18	35	12	2	2.6	18	6	11	11
717	16	M		1.27	5.3	1.025	995	740	30	22	10	18	35	12	4	3.3	14	6	11	11
725	17	M	Oct	[a] 2.21	6.2	1.011	290	2,500	12	30	8	0	0	0	1	2.0	33	8	17	12
726	15	M		[a] 2.37	5.7	1.016	600	1,360	21	29	11	0	0	0	1	1.3	9	8	17	12
746	16	M	Nov	[a] 1.79	5.7	1.017	500	1,160	15	17	15	17	34	9	2	2.4	14	5	11	8
747	15	M		[a] 1.63	6.3	1.012	450	780	18	14	28	17	34	9	1	1.1	17	5	11	8
750	16	M	Dec	[a] 2.09	5.4	1.016	675	1,320	13	17	8	0	0	0	1	1.4	33	3	6	5
751	16	M		[a] 1.89	6.5	1.011	270	3,075	<10	<15	6	0	0	0	1	1.8	25	3	6	5

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

Table 8. Radiobioassay results, food and urine, ITDSN, Sioux Falls, S. Dak., 1966

ID	Age	Sex	Date	Urine							Food	Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137 (pCi/day)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
								(pCi/liter)	(pCi/day)			(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																	
65	11	F	Jan	[a] 0.210		1.025	[a] 220	150	33	40	120	4	0.9	56	14	24	17
66	11	F		.392	6.6	1.020	350	89	31	33	120	5	1.6	25	14	24	17
77	11	F	Feb	.750	5.9	1.028	520	52	27	20	75	2	.8	57	13	25	17
78	11	F		[a] .280	6.8	1.018	[a] 250	48	12	11	75	4	.9	100	13	25	17
99	11	F	Mar	.456	6.8	1.026	[a] 240	100	24	32	110	10	2.5	93	14	25	17
135	11	F	Apr	[a] .286	6.4	1.028	[a] 120	217	26	28	110	8	.9	20	17	29	12
136	11	F		[a] .386	5.9	1.027	[a] 210	110	23	19	110	10	2.0	33	17	29	13
161	11	F	May	.707	6.2	1.017	900	51	46	16	70	1	1.0	18	14	24	10
162	11	F		.468	6.2	1.019	440	93	41	36	70	3	1.2	63	14	24	10
200	11	F	June	[a] .189	6.7	1.010	370	19	7	11	55				12	19	8
197	12	F		.548	6.5	1.019	580	72	38	26	55	2	1.3	13	12	19	8

[a] Values outside of the normal range, and excluded from further evaluation.

146

Table 9. Radiobioassay results, food and urine, ITDSN, Austin, Texas, 1966–1967

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
82	11	M	Jan	0.725	6.1	1.022		770	29	22	10	20	30	15	4	2.9	24	8	13	13
83	10	M		.555	6.6	1.021		460	61	28	21	20	30	15	2	1.0	33	8	13	13
103	11	M	Feb	.900	5.9	1.017		980	35	34	19	15	25	10	1	.8	18	7	12	12
104	10	M		.600	6.0	1.023		600	53	32	28	15	25	10	5	2.7	34	7	12	12
137	10	M	Mar	[b].326	6.0	1.021		[b]340	38	13	21	25	40	17	4	1.8	34	7	12	12
138	11	M		[b].362	6.2	1.026		355	28	10	16	25	40	17	3	1.2	17	7	12	12
158	11	M	Apr	.472	8.4	1.020		660	55	36	43	25	40	18	4	2.8	35	6	10	13
159	10	M		[b].271	7.9	1.018		460	26	12	11	25	40	18	3	1.6	10	6	10	13
191	12	M	May	.522	6.2	1.020		580	26	15	15	15	25	13	4	2.2	13	6	10	10
192	11	M		.860	6.5	1.016		970	31	30	21	15	25	15	1	1.2	24	6	10	10
227	12	M	June	.562	6.0	1.015		560	<10			25	40	20	3	1.4	10	10	17	21
228	9	M		.488	6.3	1.015		400	<10			25	40	20	3	1.3		10	17	21
240	9	F	July	.400	5.7	1.018		830	12	10	9	15	30	10	[b]25	21.0	191	7	13	14
241	11	M		.750	5.9	1.017		1,340	21	28	16	15	30	10	1	1.1	21	7	13	14
248	11	M	Aug	.400	5.5	1.024		[b]335	39	13	9	15	20	11	5	1.6	40	8	12	14
285	11	M	Sept	[b].174	7.3	1.018		[b]130	<10			10	20	9	11	6.6	1,100	7	15	19
286	9	M	Oct	.730	6.2	1.016		580	<10	< 2		15	25	11	5	1.6	32	7	11	12
338	9	M	Nov			1.015		300	50	15	30	5	5	3				7	10	17
339	10	M				1.017		600	17	10	6	5	5	3				7	10	17
359	9	M	Dec			1.015		[b]200	45	9	13	15	25	12				7	12	14
360	11	M				1.014		1,340	14	19	9	15	25	12				7	12	14
1967																				
382	10	M	Jan	.50	4.9	1.028		[b]300	<10	< 2	6	15	25	10	1	.3	14	8	13	13
383	9	M		.97	5.9	1.025		830	27	22	25	15	25	10	2	1.8	17	8	13	13
401	11	M	Feb	[b].29	5.4	1.012		450	13	6	32	5	10	6	2	.1	33	6	9	15
402	10	M		.48	4.8	1.025		390	21	8	19	5	10	6	3	1.3	27	6	9	15
426	11	M	Mar	1.03	6.0	1.017		900				10	20	8	3	2.4	50	5	9	8
427	10	M		[b].28	5.3	1.022		[b]190				10	20	8	7	1.3	140	5	9	8
473	9	M	Apr	.90	9.0	1.020	836	960	25	24	15	10	15	7	1	1.3	50	7	8	8
474	10	M		.84	6.3	1.018	692	1,200	31	37	16	10	15	7	2	2.7	33	7	8	8
489	11	M	May	[b].04	6.5	1.010	464	[b]91				5	10	5				5	5	8
490	10	M		[b].19	5.1	1.024	871	[b]240	<10	< 1	14	5	10	5	3	.8	75	5	5	8
505	9	M	June	.54	7.7	1.020	825	600	17	10	9	15	25	10	2	1.2	[b]100	5	9	8
506	10	M		.80	6.0	1.027	1,300	500	21	11	11	15	25	10	7	3.7	[b]100	5	9	8
523	10	M	July									0	0	0				3	6	6
524	11	M		.53	5.7	1.025	171	[a]240	<10	< .5	2	0	0	0				3	6	6
539	12	M	Aug	1.20	5.9	1.016	527	480	<10	< 2	11	0	0	0	3	1.2	43	8	12	13
540	10	M		.70	6.5	1.020	723	[b]250	11	3		0	0	0	11	2.8	110	8	12	13
549	10	M	Sept	[b].33	5.8	1.023	912	[b]225	<10	< 1	11	0	0	0	2	.5	13	5	8	9
550	11	M		[b].27	5.3	1.022	981	[b]140	<10	< 1	33	0	0	0	4	.5	44	5	8	9
562	11	M	Oct	.70	6.0	1.015	555	1,000	10	10	10	0	0	0	2	.2	7	4	7	8
563	11	M		1.09	6.2	1.023	920	1,025	23	24	9	0	0	0	2	2.1	22	4	7	8
569	10	M	Nov	[b].14	6.9	1.030	871	[b]125				0	0		17	2.1	189	6	10	10
570	11	M		.91	5.7	1.025	1,200	700	13	9	7	0	0		4	3.0	44	6	10	10
595	11	M	Dec	[b].14	5.3	1.030	1,350	[b]95				0	0	0				7	13	13

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

Table 10. Radiobioassay results, food and urine, ITDSN, Burlington, Vt., 1966–1967

ID	Age	Sex	Date	Urine								Food			Urine			Food		
				Creatinine (g/day)	pH	Specific gravity	Osmolality (mOs/kg)	Volume (ml)	Cesium-137		^{137}Cs/K (pCi/g)	Cesium-137		^{137}Cs/K (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)	Strontium-90		^{90}Sr/Ca (pCi/g)
									(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)		(pCi/liter)	(pCi/day)		(pCi/kg)	(pCi/day)	
1966																				
57	11		Jan	0.730	5.4	1.932		400	131	52	28	65	85	39	12	4.8	53	12	16	18
58	10			.550	5.7	1.020		500	54	27	16	65	85	39	3	1.3	76	12	16	18
81	12		Feb	.540	6.8	1.016		900	43	39	23	40	55	28	4	3.8	292	13	18	18
95	9		Mar	.485	5.7	1.028		425	129	55	33	45	55	31	13	5.7	228	11	13	16
98	11			.640	6.1	1.022		800	59	47	29	45	5	31	5	3.6	55	11	13	16
132	12		Apr	1.188	6.7	1.021		540	69	37	26	50	60	30	5	2.9	41	11	13	19
133	11			[b] .310	7.4	1.021		[b] 275	76	21	14	50	60	30	7	1.8	51	11	13	19
160	9		May	[b] .268	8.8	1.020		480	58	28	30	55	70	35	5	2.2	55	16	20	22
189	9		June	[b] .365	5.9	1.024		320	72	23	43	40	50	28	4	1.2	32	13	15	21
190	11			.510	6.5	1.026		440	91	40	36	40	50	28	5	2.0	26	13	15	21
215	9		July	.540	5.9	1.019		540	70	38	36	45	60	25	4	2.1	23	15	20	22
216	11		Aug	.560	6.2	1.023		500	114	57	33	40	45	30	7	3.4	38	7	8	12
244	10		Sept	[b] .168	7.1	1.018		[b] 300	67	20	24	30	35	21	4	1.2	44	9	11	18
245	9			.387	5.9	1.027		380	47	18	17	30	35	21	4	1.4	25	9	11	18
281	9		Oct	.378	6.6	1.010		860	20	17	12	30	40	18				12	15	19
282	11			.595	6.3	1.027		[b] 320	69	22	15	30	40	18	10	3.2	333	12	15	19
340	11		Nov			1.019		580	67	39	24	40	55	20				12	17	19
341	12					1.022		680	76	52	19	40	55	20				12	17	19
354	14		Dec			1.026		860	64	55	35	30	40	19				10	13	12
355	11					1.018		560	36	20	11	30	40	19				10	13	12
1967																				
370	11		Jan	.70	5.7	1.014		1,000	26	26	12	30	40	15	1	.8	25	13	17	19
371	11			.63	5.8	1.026		520	29	15	12	30	40	15	3	1.5	30	13	17	19
396	11	M	Feb	[a] .14	6.3	1.026		[a] 130	13	2	12	20	25	10	13	1.7	19	12	16	18
397	12	M		.96	4.7	1.020		1,000	33	33	16	20	25	10	1	1.4	17	12	16	18
421	10		Mar	.58	6.0	1.026		370	<10	<1		30	35	18	3	1.2	50	11	13	12
422	10			.60	6.3	1.020		550	15	8	11	30	35	18	3	1.4	150	11	13	12
459	10		Apr	[a] .35	6.1	1.026	1,020	[a] 290	12	3	6	15	15	9	3	1.0	21	13	12	17
460	12			.71	5.8	1.030	981	380	22	8	28	15	15	9	3	1.2	23	13	12	17
487	12	F	May	.67	5.9	1.015	640	800	10	8	5	20	25	13	1	.9	33	11	13	14
488	12			1.05	5.5	1.032	1,066	780	16	12	6	20	25	13	1	.9	50	11	13	14
495	10	M	June	.68	5.5	1.022	891	570	<10	<5		15	15	7	5	2.7	45	8	9	13
496	11	M		[a] .24	5.4	1.015	645	[a] 300	18	5	36				8	2.4	267	8	9	13

[a] Values outside of the normal range, but included in evaluation.

[b] Values outside of the normal range, and excluded from further evaluation.

148

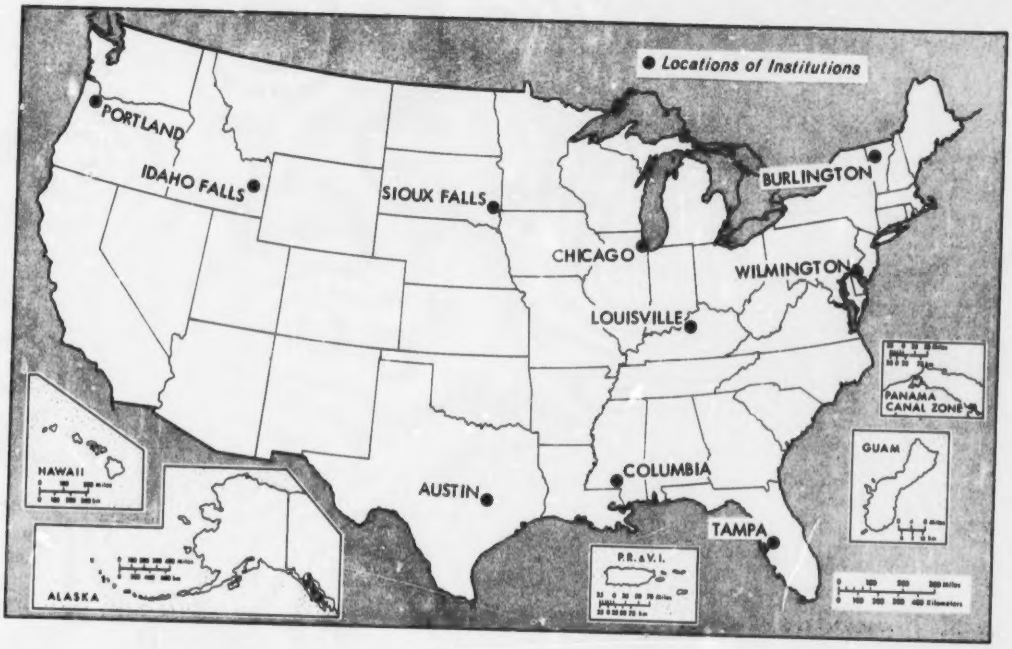
● Locations of Institutions
PORTLAND
IDAHO FALLS
SIOUX FALLS
CHICAGO
BURLINGTON
WILMINGTON
LOUISVILLE
COLUMBIA
AUSTIN
TAMPA
HAWAII
ALASKA
PANAMA CANAL ZONE
GUAM
P.R. & V.I.

Figure 1. Locations of institutions

(*6*) MOGHISSI, A. A., M. G. MAYES, and M. W. CARTER. Radiobioassay program of the Institutional Total Diet Sampling Network: IV. Evaluation of the ^{90}Sr data for children. Proceedings of the Second International Conference on Strontium Metabolism, Glasgow, Scotland, August 16–18, 1972 (in press).

(*7*) CLARK, Jr., L. C. and H. L. THOMPSON. Determination of creatine and creatinine in urine. Anal Chem 21:1218 (October 1949).

(*8*) CAHILL, D. F. and G. I. LINDSEY. Determination of strontium-90 in urine by anion exchange. Anal Chem 38:639 (1966).

(*9*) BUREAU OF RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples, January–March 1966. Radiol Health Data Rep 7:580–583 (1966); April–June 1966, 8:15–18 (January 1967); July–September 1966, 8:209–212 (April 1967); October–December 1966, 8:388–391 (July 1967); January–March 1967, 8:591–596 (October 1967); April–June 1967, 9:34–36 (January 1968); July–September 1967, 9:217–220 (April 1968); October–December 1967, 9:359–363 (July 1968); January–March 1968, 9:557–560 (October 1968); April–June 1968, 10:22–25 (January 1969); July–September 1968, 10:150–152 (April 1969); October–December 1968, 10:308–311 (July 1969).

Mention of commercial products used in connection with work reported in this article does not constitute an endorsement by the Environmental Protection Agency.

State Environmental Radioactivity Surveillance Programs, 1972

Mary Ann Culliton[1]

This report presents a summary of State environmental radioactivity surveillance programs for 1972. Information is given in table form on sample media, sites, collection and analysis frequency, and types of analysis performed.

This report summarizes environmental radioactivity surveillance programs conducted by State agencies during 1972. These surveillance programs are conducted by States in partial fulfillment of their obligation to assure a quality environment and to protect the health and safety of the public. Information is given on sample media, sites, collection and analysis frequency, and the types of analyses performed. The total area and resident population of each State are also included.

Data made available to the Office of Radiation Programs, EPA, from the operation of these programs will be included in the National Environmental Radiation Data System now being designed and developed. This system will serve as a central source of environmental radiation data which can be used to assess the impact of environmental radioactivity on a national basis. The data will be used to assist in the analysis of radiological conditions for any area of the United States and will provide information for the detection of trends, long-term buildup of radioactivity, and to assess the influence of nuclear industry effluents on environmental conditions.

Most State radioactivity surveillance programs were started in the 1950's when fallout from nuclear weapons testing contributed significantly to natural background radiation levels. With fallout becoming less important as a source of environmental radioactivity, the data from these surveillance programs are now used to measure ambient levels, trends, environmental concentration factors and as a base for evaluating the environmental impact of nuclear industry effluents.

Many States have changed their routine surveillance programs to intensive sampling near nuclear facilities which discharge radioactivity to the environment. The analyses of these source-oriented samples are more detailed than the fallout program measurements and include analyses for specific radionuclides related to the nuclear facility discharges. These measurements can be used to compare the contribution of nuclear industry discharges to ambient radioactivity levels. They can also be used in some instances to confirm compliance with environmental standards.

In addition to the State surveillance programs summarized in this report, environmental radioactivity surveillance programs are conducted by other organizations in support of their activities. These organizations include the Environmental Protection Agency, Atomic Energy Commission, universities, and nuclear facility operators.

---

[1] Ms. Culliton is with the Surveillance Branch, Field Operations Division, Office of Radiation Programs, Environmental Protection Agency, 401 M St., S.W., Washington, D.C. 20460.

150

Table 1. Summary of State environmental surveillance programs, 1972

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
ALABAMA													
Population: 3 ,444,200 Area: 51,609 mi²													
Air:													
General	2	Monthly	Monthly		X	X							
	1	Monthly	Monthly			X							
Source oriented:													
Browns Ferry	8	Monthly	Monthly			X							
Milk:													
General	19	(a)	6/annum				X	X	X	X	X	X	
Source oriented:													
Browns Ferry:													
Raw	1	Monthly	Monthly				X	X	X	X	X	X	
Pasteurized	4	Monthly	Monthly				X	X	X	X	X	X	
Miscellaneous:													
General:	0												
Source oriented:													
Browns Ferry:													
External radiation (TLD)	15	Quarterly	Quarterly										(b)
Soil	4	Quarterly	Quarterly	X	X	X							
Vegetation	4	Quarterly	Quarterly	X	X	X						X	
Fish mussels	1	Semiannually	Semiannually	X	X	X						X	
Silt	1	Not reported	Not reported	X	X	X						X	
Water:													
General:													
Surface	26	Quarterly	Quarterly			X							
Source oriented:													
Browns Ferry:													
Surface, public supply	2	Weekly composite	Monthly		X	X							
Surface, public supply	2	Quarterly	Quarterly			X							

[a] Bimonthly to monthly.

[b] Gross gamma radioactivity.

ALASKA

Population: 302,200
Area: 586,412 mi²

Air	0
Milk	0
Miscellaneous	0
Water	0

ARIZONA

Population: 1,772,500
Area: 113,909 mi²

Air	0
Milk	0
Miscellaneous	0

Water:
Arizona conducts a gross alpha and beta analysis on all new public water supplies.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
ARKANSAS													
Population: 1,923,300 Area: 53,104 mi^2													
Air:													
General	1	3/week	3/week			X							
Source oriented:													
SEFOR	1	3/week	3/week	(a)		X							
Milk:													
General	8	Monthly	Monthly				X	X	X	X	X	X	
Source oriented:													
SEFOR	4	Monthly	Monthly				X	X	X	X			
ANO	4	Quarterly	Quarterly				X	X	X	X			
ANO	3	Quarterly	Quarterly				X	X	X	X	X	X	
Miscellaneous:													
General	0												
Source oriented:													
SEFOR:													
Silt	2	Quarterly	Quarterly		X	X	X	X	X	X			(b,c)
Soil	4	Quarterly	Quarterly		X	X	X	X	X	X			(b,c)
Vegetation	4	Quarterly	Quarterly		X	X	X	X	X	X			(b,c)
ANO:													
Silt	6	Semiannually	Semiannually		X	X	X	X	X	X			(b,c)
Soil	3	Semiannually	Semiannually		X	X	X	X	X	X			(b,c)
Vegetation	5	Semiannually	Semiannually		X	X	X	X	X	X			(b)
Food	3	Semiannually	Semiannually		X	X	X	X	X	X			(b)
Thyroid (beef)	2	Monthly	Monthly				X	X	X	X			(b)
Water:													
General:													
Precipitation	1	As available	As available			X	X	X	X	X			(b)
Ground and surface public supplies	462	Triennial	Triennial		X	X							
Source oriented:													
SEFOR:													
Surface	5	Quarterly	Quarterly		X	X	X	X	X	X			(b)
ANO:													
Surface	4	Semiannually	Semiannually		X	X	X	X	X	X			(b)
Ground	2	Semiannually	Semiannually		X	X	X	X	X	X			(b)

[a] Gamma scan if beta is high.
[b] ^{144}Ce, ^{106}Ru, ^{95}Zr, ^{54}Mn, ^{65}Zn.
[c] ^{232}Th, ^{214}Bi.

ANO, Arkansas Nuclear One.
SEFOR, Southwest Experimental Fast Oxide Reactor.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
CALIFORNIA													
Population: 19,953,100 Area: 158,693 mi^2													
Air:													
General	10	5/week	Daily	(a)		X					(a)	(a)	
	2	7/week	Daily	(a)		X					(a)	(a)	
	1	7/week	Daily	(a)	X	X					(a)	(a)	
	1	5/week	Daily	(a)	X	X					(a)	(a)	
Source oriented:													
Diablo Canyon	2	1/year	Annually	X		X							
Humboldt Bay	1	1/year	Annually	X		X							
San Onofre	2	1/year	Annually	X		X							
Rancho Seco	1	1/year	Annually	X		X							(b)
Diet:													
General	20	21 meals	Quarterly	X				X			X	X	(c)
Source oriented	0												
Milk:													
General:													
Pasteurized	10	Monthly	Monthly	X			X	X	X	X	X	X	(d)
Powdered	3	Monthly	Monthly	X			X	X	X	X	X	X	
Source oriented:													
Diablo Canyon	2	Annually	Annually	X			X						
Humboldt Bay	2	Annually	Annually	X			X						
Rancho Seco	3	Annually	Annually	X			X						
Miscellaneous:													
General:													
Sewage	20	Monthly	Monthly		X	X							
Sewage	3	Quarterly	Quarterly		X	X							

See footnotes at end of table.

152

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
CALIFORNIA—continued													
Source oriented:													
San Onofre:													
Film badge	11												(e)
Cucumber, tomato, bell pepper cauliflower, green cabbage	5	Annually	Annually	X		X				X			
Femur, thyroid (rabbit)	1	Annually	Annually	X			X			X	X	X	
Soil	5	Annually	Annually										(f)
Kelp, bass, spiney crab, rock crab, etc	3	Annually	Annually				X			X			
Humboldt Bay:													
Brown algae	3	Annually	Annually			X							
Bovine thyroid	1	Annually	Annually	X			X						
Crab, fish, shrimp, gaper clam	1	Annually	Annually			X							
Pacific oyster	1	Annually	Annually	X		X							
Bottom sediment	3	Annually	Annually	X		X							
Diablo Canyon:													
Kelp, brown algae, rockfish, clam, salmon, etc	7	Annually	Annually	X		X							
External radiation (TLD)	6	Annually	Annually										(e)
Diablo Canyon:													
Bovine thyroid	1	Annually	Annually	X			X						
Leafy vegetables	1	Annually	Annually	X		X							([illegible])
Red abalone	1	Annually	Annually	X		X							([illegible])
Leaf barnacles and/or mussels	1	Annually	Annually	X		X							([illegible])
Rockfish	1	Annually	Annually	X		X							([illegible])
Bottom sediment	1	Annually	Annually	X									([illegible])
Rancho Seco:													
Vegetation	3	Annually	Annually	X		X	X						
External radiation (TLD)	6	Annually	Annually										
Grazing animal thyroid	2	Annually	Annually	X			X						
Mud and silt	2	Annually	Annually	X		X	X						
Water:													
General:													
Precipitation	1	(g)	(g)			X		MC			MC	MC	(h)
Wet and dry fallout	3	Monthly	Monthly					X			X	X	(h)
Ground, public supply	5	Monthly	Monthly			X		YC			YC	YC	(i)
Surface, public supply	7	Monthly	Monthly			X		YC			YC	YC	(i)
Surface, public supply	1	9/year	9/year			X		YC			YC	YC	(i)
Surface, public supply	1	8/year	8/year			X		YC			YC	YC	(i)
Surface, public supply	1	11/year	11/year			X		YC			YC	YC	(i)
Surface, public supply	1	Semiannually	Semiannually			X		YC			YC	YC	(i)
Surface, public supply	2	8/year	8/year			X		YC				YC	(i)
Surface, public supply	1	11/year	11/year			X		YC				YC	(i)
Source oriented:													
Diablo Canyon:													
Sea water	1	Annually	Annually			X							([illegible])
Humboldt Bay:													
Public supply	1	Annually	Annually			X							
San Onofre:													
Public supply	2	Annually	Annually			X							
Secondary cooling	1	Annually	Annually			X				X			
Rancho Seco:													
Public supply	1	Annually	Annually			X				X			
Secondary cooling	1	Annually	Annually			X				X			
Offsite drainage	2	Annually	Annually			X				X			

---

[a] Monthly composite.
[b] ^{95}Zr-^{95}Nb.
[c] ^{226}Ra, ^{54}Mn, ^{95}Zr-Nb, $^{141-144}$Ce, Na, Ca, K.
[d] ^{54}Mn, ^{95}Zr-Nb, Ca, ^{106}Ru-Rh, $^{141-144}$Ce.
[e] Gross gamma.
[f] Stored.
[g] Every 24 hours when rain occurs.
[h] ^{54}Mn, ^{95}Zr-Nb, ^{106}Ru-Rh, $^{141-144}$Ce—monthly composite.
[i] ^{54}Mn, ^{95}Zr-Nb, $^{141-144}$Ce, ^{226}Ra—one year composite.
MC, monthly composite.
YC, yearly composite.

153

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
COLORADO													
Pop: 2,207,300 Area: 104,247 mi^2													
Air:													
General	46	1/4 days	1/4 days	(a)	X	X							(b)
Source oriented:													
Rocky Flats and Fort St. Vrain	3	1/4 days	1/4 days	(a)	X	X							(b)
Nuclear Generating Plant	4	1/4 days	1/4 days	(a)	X	X							^{239}Pu [b]
Fort St. Vrain Nuclear Generating Plant	15	1/4 days	1/4 days	(a)	X	X							(b)
Rocky Flats	11	1/4 days	1/4 days	(a)	X	X							(b)
	4	1/4 days	1/4 days	(a)	X	X							^{239}Pu [b]
	5	1/48 hour	1/48 hour	(a)	X	X							^{239}Pu [b]
Rulison Project	8	1/4 days	1/4 days	(a)	X	X							(b)
Milk:													
General	6	Monthly	Monthly	X			X	X	X	X			
	1	Monthly	Monthly	X			X	X	X	X			
	1	Monthly	Monthly	X			X	X	X	X			
Source oriented:													
Rulison Project	6	Sporadic	As collected				X	X	X	X			
Miscellaneous	0												
Water:													
General:													
Surface	122	Quarterly	Quarterly	------	X	X							^{226}Ra
Public supply	451	Biannually	Biannually	------	X	X							^{226}Ra
Source oriented:													
Rocky Flats:													
Surface	1	48 hours	48 hours	------	X	X							
Fort St. Vrain Nuclear Generating Plant													
Surface	8	Monthly	Monthly	X	X	X							^{3}H
Rulison Project:													
Surface	24	Sporadic	Sporadic		X	X							^{226}Ra
	3	Quarterly	Quarterly	------	X	X							^{3}H,[e]
Uravan-Uranium Mill:													
Surface	4	Standby	Standby										^{226}Ra
	3	Monthly	Monthly		X	X							^{226}Ra
Ground	1	Standby	Standby										^{226}Ra
Public supply	2	Monthly	Monthly		X								(d)
Effluent and waste water	3	Monthly	Monthly		X	X							^{226}Ra
Special ^{3}H Network	8	Monthly	Monthly										(e)

---

[a] If sample exceeds normal gross alpha and/or gross beta background concentrations.
[b] Alpha spectrum—if sample exceeds normal gross alpha concentration.
[c] ^{226}Ra analysis done when sample shows gross alpha >10 pCi/liter.
[d] ^{238}U natural series.
[e] ^{3}H analysis done by National Environmental Research Center—Las Vegas, Nevada.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
CONNECTICUT													
Pop: 3,032,200 Area: 5,009 mi^2													
Air	0												
Milk:													
General	(a)	Monthly	Monthly				X	X	X		X	X	
Source oriented:													
Haddam Neck	[b]3	Quarterly	Quarterly				X	X	X	X	X	X	
Millstone Station	[b]3	Quarterly	Quarterly				X	X	X	X	X	X	
Miscellaneous:													
General:													
Sewage	3	Annually	Annually	------	X	X							
Source oriented:													
Haddam Neck:													
Sediment	4	Monthly	Monthly	X	------	X							
Fish	1	Semiannually	Semiannually	X	------	X							
Fodder	3	Semiannually	Semiannually	X									
Millstone Station:													
Sediment	5	Quarterly	Quarterly	X	------	X							
Shellfish	2	Semiannually	Semiannually	X	------	X							
Fodder	3	Semiannually	Semiannually	X									
Nuclear submarine facilities in New London Harbor:													
Sediment	7	2/quarter	2/quarter	X	------	X							

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
CONNECTICUT—continued													
Water:													
General:													
Reservoir, public supply	6	3/year	3/year		X	X							
River water	7	Quarterly	Quarterly		X	X							^{3}H
	14	Quarterly	Quarterly			X							
Sea water	1	Quarterly	Quarterly			X							^{3}H
Source oriented:													
Haddam Neck:													
Reservoir, public supply	6	3/year	3/year		X	X							
River water	6	Monthly	Monthly	X	X	X							^{3}H
Well water	4	Quarterly	Quarterly		X	X							^{3}H
Millstone Station:													
Reservoir, public supply	3	3/year	3/year		X	X							
Sea water	6	Quarterly	Quarterly	(c)		X							^{3}H
Well water	1	Quarterly	Quarterly		X	X							^{3}H
Nuclear submarine facilities in New London Harbor:													
Sea water	7	2/Quarter	2/Quarter	(d)		X							^{3}H
United Nuclear Corporation:													
Reservoir, public supply	2	3/year	3/year		X	X							
River water	1	Quarterly	Quarterly			X							
Combustion Engineering and S1C Prototype Reactor:													
River water	2	Quarterly	Quarterly		X	X							^{3}H

[a] Pasteurized milk is collected monthly from several distributors and then combined as a composite sample representative of milk sold in the central area of the State.

[b] Raw milk from farm.

[c] Gamma spectrum on sample from Millstone quarry outfall.

[d] Gamma spectrum on sample from Electric Boat Div. rad. waste facility.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
DELAWARE													
Pop: 548,100 Area: : 2,057 mi²													
Air	0												
Milk:													
General	8	Monthly	Monthly									X	
Source oriented	0												
Miscellaneous:													
General:													
Sediment	14	Monthly	Monthly		X	X							
Biota	14	Monthly	Monthly		X	X							
Source oriented	0												
Water:													
General:													
Surface	14	Monthly	Monthly		X	X							
Ground	6	Annually	Annually		X	X						X	^{226}Ra
Source oriented	0												

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
DISTRICT OF COLUMBIA													
Pop: 756,500 Area: 67 mi²													
Air:													
General	1	Daily	Daily			X							
Source oriented	0												
Milk	0												
Miscellaneous	0	As needed											
Water:													
General													
Surface	1	Daily	Daily		X	X							
Public supply	2	Daily	Daily		X	X							
Sewage influent	1	Daily	Weekly		X	X							
Source oriented	0												

155

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
FLORIDA													
Population: 6,789,400													
Area: 58,560 mi^{2}													
Air:													
General:	2	3/week	3/week		X	X							(a)
Source oriented:													
Turkey Point	8	Weekly	Weekly	(b)		X	X						(a)
Crystal River	5	Weekly	Weekly	(b)		X	X						(a)
Cape Kennedy	1	3/week	3/week			X							(a)
Hutchinson Island	8	Weekly	Weekly	(b)			X						
Milk:													
General:													
Raw	6	Monthly	Monthly				X	X	X	X	X	X	
Source oriented:													
Crystal River:													
Raw	1	Quarterly	Quarterly				X	X	X	X	X	X	
Hutchinson Island:													
Raw	6	Quarterly	Quarterly				X	X	X	X	X	X	
Miscellaneous:													
Source oriented:													
Turkey Point:													
Biota	17	Quarterly	Quarterly	X								X	
Sargassum	8	Semiannually	Semiannually	X								X	
Mangrove	7	Quarterly	Quarterly	X								X	
Algae fresh water	3	Semiannually	Semiannually	X								X	
Turtle grass	7	Semiannually	Semiannually	X								X	
External radiation (TLD)	11	Monthly	Monthly										(c)
External radiation (Victoreen Ion Chamber)	8	Monthly	Monthly										(c)
Soil	11	Semiannually	Semiannually	X								X	
Silt	17	Quarterly	Quarterly	X								X	
Small animal	1	Semiannually	Semiannually	X								X	
Food crops	5	Semiannually	Semiannually	X								X	
Crystal River:													
Oysters	7	Quarterly	Quarterly	X		X						X	^{32}P
Crabs	1	Quarterly	Quarterly	X		X						X	^{32}P
Soil	10	Semiannually	Semiannually	X		X							
Silt	4	Quarterly	Quarterly	X		X							
Citrus	1	Quarterly	Quarterly	X		X						X	
Vegetation	10	Monthly	Monthly	X		X							
External radiation (TLD)	5	Monthly	Monthly										(c)
Hutchinson Island:													
External radiation (TLD)	8	Monthly	Monthly										(c)
Silt	7	Semiannually	Semiannually	X								X	
Soil	8	Semiannually	Semiannually	X								X	
Crustacea	9	Quarterly	Quarterly	X								X	
Fish	9	Quarterly	Quarterly	X								X	
Fresh water plants	2	Semiannually	Semiannually	X								X	
Food crops	6	Semiannually	Semiannually	X								X	
Water:													
General:													
Precipitation	2	3/month	3/month			X							
Source oriented:													
Turkey Point:													
Bay water	11	Monthly	Monthly	X								X	(d)
Surface (canal)	3	Quarterly	Quarterly	X		X							(d)
Public supply	3	Quarterly	Quarterly			X							^{3}H
Ground	2	Quarterly	Quarterly			X							^{3}H
Precipitation	4	Monthly	Monthly			X							^{3}H
Crystal River:													
Sea water	2	Quarterly	Quarterly			X							(d)
Sea water	4	Quarterly	Quarterly	X		X							(d)
Public supply	4	Quarterly	Quarterly	X		X							^{3}H
Surface	4	Quarterly	Quarterly	X		X							^{3}H
Potable ground	1	Quarterly	Quarterly	X		X							^{3}H
Ground	1	Quarterly	Quarterly	X		X							^{3}H
Hutchinson Island:													
Sea water	9	Quarterly	Quarterly	X								X	^{3}H
Surface water	3	Quarterly	Quarterly	X		X							^{3}H
Public supply	4	Quarterly	Quarterly	X		X							^{3}H
Precipitation	4	Monthly	Monthly	X		X							^{3}H

[a] Specific nuclides if necessary.
[b] Monthly composite.
[c] Direct radiation.
[d] ^{3}H, ^{58}Co, ^{60}Co.

156

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
GEORGIA													
Population 4,589,600 **Area: 58,876 mi^2**													
Air:													
General	3	3/day	Daily	-----	-----	X							
Source oriented:													
Georgia Tech Reactor	2	2/week	2/week	-----	X	X							
Milk—Program on standby since 1964													
Miscellaneous	0												
Water:													
General	0												
Source oriented:													
Lockheed Radiation Effects Reactor:													
Surface	6	Weekly	Weekly	-----	X	X	-----	-----	-----	-----	-----	-----	(a)

---

[a] ^{60}Co, ^{54}Mn, ^{56}Mn, ^{24}Na, ^{51}Cr.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
HAWAII													
Population: 769,900 **Area: 6,450 mi^2**													
Air:													
General	3	5/week	5/week	-----	-----	X							
Source oriented	0												
Milk:													
General	3	Annually [a]	Annually [a]	-----	-----	-----	X	X	X	-----	-----	X	
Source oriented	0												
Miscellaneous	0												
Water:													
General:													
Ground, public supply	20	Annually	Annually	-----	-----	X	X	X	-----	-----	-----	(b)	
Surface, public supply	15	Annually	Annually	-----	-----	X	X	X	-----	-----	-----	(b)	
Source oriented	0												

---

[a] Frequency is increased during atmospheric tests.

[b] Strontium-90 analysis is done only when gross beta indicates probability of the radionuclide being present.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
IDAHO													
Population: 713,000 **Area: 83,557 mi^2**													
Air:													
General	4	Standby [a]	Standby [a]	X	X	X	X						
Source oriented	0												
Milk:													
General	3	Standby [a]	Standby [a]	-----	-----	-----	X	X	X	X	X	X	
Source oriented	0												
Miscellaneous	0												
Water	0												

---

[a] All standby stations can be activated within a few hours' notice.

157

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
ILLINOIS													
Population: 11,114,000 Area: 56,400 mi²													
Air:													
General	2	Daily	Daily	------	X	X							
Source oriented:													
Dresden	1	Daily	Daily	------	X	X							
Milk-on standby[a]													
Miscellaneous:													
General:													
External radiation (TLD)	11	Quarterly	Quarterly	------	------	------	------	------	------	------	------	------	(b)
Source oriented:													
Quad-Cities:													
External radiation (TLD)	8	Quarterly	Quarterly	------	------	------	------	------	------	------	------	------	(b)
Zion:													
External radiation (TLD)	7	Quarterly	Quarterly	------	------	------	------	------	------	------	------	------	(b)
Dresden:													
External radiation (TLD)	17	Quarterly	Quarterly	------	------	------	------	------	------	------	------	------	(b)
Water:													
General	0												
Source oriented:													
Sheffield Burial Site:													
Ground and surface	11	Quarterly	Quarterly	------	X	X	------	(c)	------	------	------	------	(c)
Quad-Cities:													
Surface	5	Quarterly	Quarterly	------	X	X							
Ground	6	Quarterly	Quarterly	------	X	X							
Dresden:													
Surface	16	Quarterly	Quarterly	------	X	X							
Ground	12	Quarterly	Quarterly	------	X	X							
Zion:													
Surface	2	Quarterly	Quarterly	------	X	X							

---

[a] Reactor oriented milk surveillance will be initiated for Dresden, Quad Cities, and Zion. These samples will be collected on a semiannual basis initially.

[b] Direct radiation (noble gases).

[c] Specific analysis if gross beta >50 pCi/liter.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
INDIANA													
Population: 5, 193,700 Area: 36,291 mi²													
Air	0												
Milk:													
General	5	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Source oriented	0												
Miscellaneous	0												
Water:													
General:													
Surface	16	Monthly	Monthly	------	X	X							
Source oriented	0												

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
IOWA													
Population 2,825,000 Area: 56,290 mi²													
Air:													
General	15	Varies	Quarterly	------	------	X							
Source oriented	0												
Milk:													
General	2	Monthly	Monthly	------	------	------	X	X	X	X		X	
	1	3-5/month	3-5/month	------	------	------	X	X	X	X		X	
Source oriented	0												
Miscellaneous	0												
Water:													
General:													
Surface	19	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{3}H
Precipitation	2	As available	As collected	------	X	X	------	------	------	------	------	------	^{3}H
Drinking water supplies	1,098	Annually	On demand	------	X	X	(a)	(a)	------	------	------	(a)	
Source oriented	0												

---

[a] Selected sites.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
KANSAS													
Population: 2,249,100 **Area: 82,264 mi^2**													
Air:													
General	1	Daily	Daily	------	------	X	------	------	------	------	------	------	^{222}Rn, ^{232}Th
Source oriented	0												
Milk:													
General													
Pasteurized	6	Monthly	Monthly	------	------	------	X	X	X	X			
Source oriented:													
Cooper Nuclear Station:													
Raw	1	Every other month	Every other month	------	------	------	X	X	X	X			
Miscellaneous:													
General:													
Soil and vegetation	4	Semiannually	Semiannually	------	X	X	------	X	------	X	------	X	^{106}Ru
External radiation (TLD)	7	1/quarter	1/quarter	X									
Source oriented:													
Research reactors, hospitals, Coleman Co.:													
Effluent studies	4	1/quarter	1/quarter	------	X	X	X	------	------	------	------	------	^{232}Th, ^{99m}Tc
Water:													
General:													
Surface	28	Monthly	Monthly	------	X	X	------	X	------	------	------	X	^{3}H, ^{226}Ra
Ground	30	Yearly	Yearly		X	X	------	X	------	------	------	X	^{3}H, ^{226}Ra
Precipitation	7	1/quarter	1/quarter		X	X	------	X	------	------	------	X	^{3}H
Source oriented	0												
KENTUCKY													
Population: 3,219,300 **Area: 40,395 mi^2**													
Air	0												
Milk:													
General	7	Quarterly	Quarterly	------	------	------	X	X	X	X	X	X	
Source oriented	0												
Water:[a]													
General:													
Surface	12	Monthly	Monthly	------	X	X							
Source oriented:													
Nuclear Engr. Corp. Morehead:													
Ground	18	Monthly	Monthly	X	X	X	------	------	------	------	------	------	^{226}Ra [b]
Gaseous diffusion plant:													
Surface	6	Annually	Annually	------	X	X							
Miscellaneous:													
General:													
Dustfall	24	Monthly	Monthly	------	X	X							
Source oriented:													
Nuclear Engr. Corp.:													
Vegetation	10	1/2 year	1/2 year	X	X	X							
Silt	10	1/2 year	1/2 year	X	X	X							
Gaseous diffusion plant:													
Silt-vegetation	6	Annually	Annually	------	X	X							

---

[a] The State is conducting a survey of all public water supplies to establish the natural radioactivity of the respective areas. The public supplies are analyzed for gross alpha and beta. This is not a routine study, and therefore, will not be repeated.

[b] Analyses done on samples collected at four sampling locations around radioactive burial grounds.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
LOUISIANA													
Population: 3,643,200 Area: 48,523 mi^2													
Air	3	5/week	5/week			X							
Milk:													
General	7	7/month	7/month				X	X	X	X		X	
Source oriented	0												
Miscellaneous:													
General:													
Farm produce	5	Annually (season)	Annually (season)	X	X	X	X	X	X	X			(a)
Source oriented	0												
Water:													
General:													
Surface	17	Monthly	Monthly		X	X							
Public supply	2	Monthly	Monthly		X	X							
Precipitation	3	Monthly	Monthly		X	X							
Source oriented	0												

[a] ^{106}Ru, ^{95}Zr, ^{65}Zn, ^{144}Ce, ^{54}Mn.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
MAINE													
Population: 993,700 Area: 33,215 mi^2													
Air:													
General	1	Daily	Daily	X	X	X							
Source oriented:													
Maine Yankee	1	Weekly	Weekly			X							
Milk:													
General	0												
Source oriented:													
Maine Yankee	1	Monthly	Monthly	X			X	X	X	X	X	X	
Miscellaneous:													
General	0												
Source oriented:													
Maine Yankee:													
External radiation (TLD)	14	13 weeks	13 weeks										(a)
Seaweed	8	Monthly	Monthly	X									
Sediment	3	13 weeks	13 weeks	X									
Shellfish	2	13 weeks	13 weeks	X									
Vegetables, hay, grass, apples	1	In season	In season	X									
Water:													
General:													
Precipitation	1	Daily	Daily	X		X							
Ground (private wells)	6	Monthly	Monthly	X		X							(b)
Source oriented:													
Maine Yankee:													
Surface, salt water	9	Weekly	Weekly	X									
Surface, public supply	4	Weekly	Weekly	X		X							

[a] Direct radiation (3 chips/station).

[b] ^{222}Rn and daughters.

160

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
MARYLAND													
Population: 3,922,400 Area: 10,577 mi²													
Air:													
General	14/1 [a]	Weekly	Weekly	-----	-----	X							
Source oriented	8 [a]	Weekly	Weekly	-----	-----	X							
Milk:													
General	1	Weekly	Weekly	-----	-----	-----	X	X	X	X	X	X	
Source oriented	0												
Miscellaneous:													
General:													
Shellfish	4	Random	Random	-----	-----	-----	-----	-----	-----	-----	X	X	
Source oriented	0												
Water:													
General:													
Precipitation	1	As collected	As collected	-----	-----	X							
Surface	3	Quarterly	Quarterly	-----	-----	X	-----	-----	-----	-----	-----	-----	^{3}H
Public supply	2	Monthly	Monthly	-----	X	X	-----	-----	-----	-----	-----	-----	^{3}H
Public supply	1	Weekly	Weekly	-----	X	X	-----	-----	-----	-----	-----	-----	^{3}H
Source oriented:													
Calvert Cliffs:													
Chesapeake Bay surface and bottom	5	Quarterly	Quarterly	-----	-----	X	-----	-----	-----	-----	-----	-----	^{3}H
Ground water	1[illegible]	Quarterly	Quarterly	-----	X	X	-----	-----	-----	-----	-----	-----	^{3}H
Surface stream	2	Quarterly	Quarterly	-----	X	X	-----	-----	-----	-----	-----	-----	^{3}H

[a] 14 intermittent and 4 continuous.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
MASSACHUSETTS													
Population: 5,689,200 Area: 8,257 mi²													
Air:													
General	40	Weekly	Weekly	-----	-----	X							
	5	5/week	Daily	-----	-----	X							
	8	5/week	Weekly	-----	-----	X							
	2	Weekly	Weekly	X	-----	X	(a)	-----	-----	-----	-----	-----	^{3}H
	1	Weekly	Weekly	X	-----	X	X	-----	-----	-----	-----	-----	^{3}H
	1	Weekly	Weekly	X	-----	X							
Source oriented	0												
Milk:													
General	1	Weekly	Weekly	-----	-----	-----	X	X	X	X	-----	MC	
Source oriented	0												
Miscellaneous:													
General:													
Shellfish	1	Quarterly	Quarterly	-----	-----	X							
Cranberries	1	2/year	2/year	-----	-----	X							
Source oriented	0												
Water:													
General:													
Ground, surface	1001	Quarterly	Quarterly	-----	X	X							
Source oriented:													
Yankee:													
Surface	9	Monthly	Monthly	-----	-----	X	-----	-----	-----	-----	-----	-----	(b)
Reactor waste	1	Monthly	Monthly	-----	-----	X	-----	-----	-----	-----	-----	-----	^{3}H
Reactor waste	1	Before discharge	Before discharge	-----	-----	X							
Lowell Technical Reactor:													
Surface	2	Monthly	Monthly	-----	-----	X							
MIT reactor:													
Reactor waste	1	Before discharge	Before discharge	-----	-----	X							
U.S. Army Materials Testing Reactor:													
Reactor waste	1	Before discharge	Before discharge	-----	-----	X							
Vermont Yankee:													
Surface (top & bottom)	4	Monthly	Monthly	-----	-----	X	X	X	X	-----	-----	X	^{3}H

[a] Initiated after an atmospheric detonation of a nuclear device.

[b] ^{3}H 2/year.

MC, monthly composite.

161

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis: γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
MICHIGAN													
Population: 8,875,100 Area: 58,216 mi²													
Air:													
General	1	Daily	Daily			X							
Source oriented:													
Palisades Reactor	4	Weekly, continuous	Weekly			X	(a)						
Enrico Fermi	4	Weekly, continuous	Weekly			X	(a)						
Big Rock Point	5	Weekly, continuous	Weekly			X	(a)						
Donald C. Cook Reactor	1	Weekly, continuous	Weekly			X	(a)						
Background	1	Weekly, continuous	Weekly			X	(a)						
Milk:													
General:													
Pasteurized	3	Biweekly	Biweekly				X	X	X	X		(b)	
	2	Monthly	Monthly				X	X	X	X		(b)	
Source oriented:													
Big Rock Point and Palisades:													
Pasteurized	2	Weekly	Weekly				X	X	X	X		(b)	
Enrico Fermi:													
Pasteurized	1	Biweekly	Biweekly				X	X	X	X		(b)	
Miscellaneous:													
General	0												
Source oriented:													
Palisades Reactor:													
External radiation (film badge-TLD)	4	Monthly	Monthly										(c)
Aquatic biota	5	Semiannually	Semiannually	X		X							
Big Rock Point:													
External radiation (film badge-TLD)	6	Monthly	Monthly										(c)
Aquatic biota	5	Semiannually	Semiannually	X		X							
Enrico Fermi:													
External radiation (film badge-TLD)	4	Monthly	Monthly										(c)
Aquatic biota	5	Semiannually	Semiannually	X		X							
Donald C. Cook Reactor:													
External radiation (film badge-TLD)	1	Monthly	Monthly										(c)
Background:													
External radiation (film badge-TLD)	1	Monthly	Monthly										(c)
Water:													
General:													
Surface, public supply	37	Alternate 3-month periods	(d)	X	X	X							
Surface, public supply	11	Quarterly	(d)	X	X	X							
Surface, river	45	Quarterly	Quarterly			X							
Source oriented:													
Palisades Reactor:													
Precipitation	4	Weekly, continuous	Weekly			X							
Surface	5	Monthly	Monthly	X		X							^{3}H
Enrico Fermi:													
Precipitation	4	Weekly, continuous	Weekly			X							
Surface	5	Monthly	Monthly	X		X							^{3}H
Big Rock Point:													
Precipitation	5	Weekly, continuous	Weekly			X							
Surface	5	Monthly	Monthly	X		X							^{3}H
Donald C. Cook Reactor:													
Precipitation	1	Weekly, continuous	Weekly			X							
Reactor oriented	1	Weekly, continuous	Weekly			X							

---

[a] Gross gamma analysis for ^{131}I involves using charcoal filter adsorption.
[b] A minimum of once/month for each site.
[c] Direct gamma radiation.
[d] Quarterly composite of daily samples.

162

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
MINNESOTA													
Population: 3,805,100 Area: 84,068 mi²													
Air:													
General	1	Daily	Daily			X							
Source oriented:													
Monticello	8	Weekly	Weekly	(a)	X	X	X						
Prairie Island	9	Biweekly	Biweekly	(a)		X	(b)						
Milk:													
General:													
Pasteurized	8	Monthly	Monthly				X	X				X	
Source oriented:													
Monticello:													
Raw	12	Monthly	Monthly				X	X				X	
Prairie Island:													
Raw	9	Monthly	Monthly				X	X				X	
Elk River:													
Raw	4	Quarterly	Quarterly				X	X				X	
Miscellaneous:													
General:													
Fallout (pot)	1	Monthly	Monthly	X		X	X					X	^{3}H
Source oriented:													
Monticello:													
Aquatic insects	8	Quarterly	Quarterly	X		X	(c)	X				X	
Aquatic vegetation	8	Quarterly	Quarterly	X		X		X				X	
Plankton, algae or insects	8	Quarterly	Quarterly	X		X	(c)	X				X	
Bottom sediment	8	2 /year	2 /year	X		X		X				X	
External radiation (TLD and film badge)	40	Monthly	Monthly										(d)
Top soil field composite	6	2 /year	2 /year	X		X		X				X	
Vegetation	3	2 /year	2 /year	X		X	X						
Potatoes and soybeans	3	Annually	Annually	X		X	X	X				X	
Fish	2	Quarterly	Quarterly	X		X				X		(e)	
Clams	2	Quarterly	Quarterly	X		X							
Fallout (pot)	1	Monthly	Monthly	X		X	X					X	^{3}H
Prairie Island:													
External radiation (TLD and film badge)	9	Monthly	Monthly										(d)
	6	Every 4 weeks	Every 4 weeks										(d)
Bottom sediment	5	2 /year	2 /year	X		X						X	
Plankton, algae, or insects	5	Annually	Annually	X		X	(c)					X	
Agricultural crops	3	Annually	Annually	X		X	X					X	
Forage	3	2 /year	2 /year	X		X	X						
Top soil, field composite	3	2 /year	2 /year	X		X						X	
Fallout (pot)	1	2 /year	2 /year	X		X						X	
Aquatic vegetation	5	2 /year	2 /year	X		X						X	
Fish	2	4 /year	4 /year	X		X						X	
Clams	2	Quarterly	Quarterly	X		X						X	
Water:													
General:													
Surface and public supply	5	Weekly	Monthly composite		X	X							^{3}H every 6 months
Surface and public supply	[illegible]	Monthly	Monthly		X	X							
Surface and public supply	1	Weekly	Weekly		X	X							
Surface	1	Monthly	Monthly	X		X						X	^{3}H
Precipitation	10	Monthly	Monthly										^{3}H
		Daily	Daily		X	X							
Source oriented:													
Monticello:													
Surface	2	Daily	Weekly composite	(b)		X						(b)	^{3}H
	1	Weekly	Weekly	(b)		X						(b)	^{3}H monthly
Ground	6	Monthly	Monthly	X		X						X	^{3}H monthly
	4	Quarterly	Quarterly		X	X						X	^{3}H
	2	Monthly	Monthly		X	X						X	^{3}H
Prairie Island:													
Surface	2	Weekly	Weekly	X		X						(f)	^{3}H
	2	Quarterly	Quarterly	X		X						X	^{3}H monthly
	1	Monthly	Monthly	X		X						(f)	^{3}H
Ground	9	Quarterly	Quarterly	X	X	X						X	^{3}H monthly

---

[a] Gamma scan done on monthly composite of all weekly samples.

[b] Monthly.

[c] ^{131}I analysis will be performed once before plant startup and yearly during operational period. If ^{131}I is higher than expected, quarterly analyses will be undertaken on insect samples.

[d] Gamma-TLD; Beta-gamma—Film Badge.

[e] ^{90}Sr determined in both fish flesh and skeleton.

[f] ^{90}Sr is analyzed quarterly.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
MISSISSIPPI													
Population: 2,216,900 Area: 47,716 mi^2													
Air	0												
Milk	0												
Miscellaneous	0												
Water	0												
MISSOURI													
Population: 4,677,400 Area: 69,686 mi^2													
Air	0												
Milk	0												
Miscellaneous	0												
Water:													
General:													
Surface, public supply	14	Monthly	Monthly		X	X							
Surface, public supply	10	6/year	6/year			X						X	^{226}Ra
Ground, public supply	10	Monthly	Monthly		X	X							
Ground, public supply	4	6/year	6/year			X						X	^{226}Ra
Ground & surface, public supply	1	Monthly	Monthly		X	X							
Source oriented	0												
MONTANA													
Population: 694,400 Area: 147,138 mi^2													
Air	0												
Milk	0												
Miscellaneous	0												
Water	0												
NEBRASKA													
Population 1,483,800 Area: 77,227 mi^2													
Air	0												
Milk	0												
Miscellaneous	0												
Water:													
General:													
Precipitation	1	As available	As collected		X	X							
Source oriented:													
Hallam Nuclear Power Facility:													
Surface	2	Semiannually	Semiannually			(a)							
Ground	9	Semiannually	Semiannually			(a)							

[a] Those individual samples showing high beta-gamma results are given a gamma spectrum analysis to ascertain the contributor. A composite of all semiannual samples is given a gamma spectrum analysis to determine the gross gamma activity.

164

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
NEVADA													
Population: 483,700 Area: 110,540 mi²													
Air	0												
Milk	0												
Miscellaneous	0												
Water	0												
NEW HAMPSHIRE													
Population: 737,700 Area: 9,304 mi²													
Air:													
General	0												
Source oriented:													
Vermont Yankee	6	Weekly	Weekly	(a)	------	X							
Milk:													
General	0												
Source oriented:													
Vermont Yankee	3	Monthly	Monthly	X	------	------	------	------	------	------	------	X	
Miscellaneous:													
General	0												
Source oriented:													
Vermont Yankee:													
Vegetation	(b)	Annually	Annually	X	------	X							
Pasturage and fodder crops	3	Semiannually	Semiannually	X	------	X							
Diet	2	Semiannually	Semiannually	X	------	X	------	------	------	------	------	X	
Soil	4	Semiannually	Semiannually	X	------	X	------	------	------	------	------	X	
Silt and benthic organisms	2	Semiannually	Semiannually	X	------	X	------	------	------	------	------	X	
Fish and shellfish	2	Semiannually	Semiannually	X	------	X	------	------	------	------	------	X	
External radiation (TLD)	7	Quarterly	Quarterly	------	------	------	------	------	------	------	------	------	(c)
Water:													
General	0												
Source oriented:													
Vermont Yankee:													
Drinking water	1	Semiannually	Semiannually	X	------	X	------	------	------	------	------	X	
Ground water	1	Quarterly	Quarterly	X	------	X	------	------	------	------	------	X	
Precipitation	2	Continuous	Quarterly	X	------	X	------	------	------	------	------	X	

---

[a] Composite for gamma scan quarterly.

[b] One each of principal agricultural crops and fruit within 10-mile radius of site within New Hampshire. One each of same principal crops and fruit from vicinity of Concord, New Hampshire.

[c] Gamma dose quarterly.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
NEW JERSEY													
Population: 7,168,200 Area: 7,836 mi²													
Air:													
General	1	Continuous	Weekly	X	------	X							
Source oriented:													
Oyster Creek	7	Continuous	Biweekly	X	------	W	W	------	------	------	Q	Q	
Air particulates—stack	1	Quarterly	Quarterly	X	------	X							
Gaseous discharges—stack	1	Quarterly	Quarterly	X									
Salem	2	Continuous	Biweekly	X	------	W	W	------	------	------	Q	Q	
Milk:													
General	2	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Source oriented:													
Salem	3	Quarterly	Quarterly	------	------	------	X	X	X	X	X	X	
Miscellaneous:													
General	0												
Source oriented:													
Oyster Creek:													
Silt	7	Semiannually	Semiannually	X									
	8	Annually	Annually	X									
Benthic algae	8	Semiannually	Semiannually	X									
Fin fish and crabs	2	Semiannually	Semiannually	X									
Clams	6	Quarterly	Quarterly	X	------	------	------	------	------	------	X	X	
Food produce	6	Annually	Annually	X	------	------	------	------	------	------	X	X	
Wildlife	2	Annually	Annually	X	------	------	------	------	------	------	X	X	
External radiation (TLD)	12	Quarterly	Quarterly										

See footnotes at end of table.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
NEW JERSEY—continued													
Salem:													
Silt	5	Annually	Annually	X									
Food produce	4	Annually	Annually	X	------	------	------	------	------	------	X	X	
External radiation (TLD)	5	Quarterly	Quarterly										
Water:													
General:													
Statewide	20	Annually	Annually	------	X	X	------	------	------	------	X	X	
Potable	21	Annually	Annually	------	X	X	------	------	------	------	(a)	(a)	(b)
Source oriented:													
Oyster Creek:													
Surface water	1	Continuous	Weekly	X	------	------	------	------	------	------	X	X	^{3}H
	2	Monthly	Monthly	X	------	------	------	------	------	------	X	X	^{3}H
Potable water	11	Semiannually	Semiannually	------	X	X	------	------	------	------	(a)	(a)	(b)
Aqueous discharges—inhouse	1	Quarterly	Quarterly	X	------	------	------	------	------	------	X	X	^{3}H
Salem:													
Surface water	2	Monthly	Monthly	X	------	------	------	------	------	------	X	X	^{3}H
	7	Semiannually	Semiannually	X	------	------	------	------	------	------	X	X	^{3}H
Potable water	5	Quarterly	Quarterly	------	X	X	------	------	------	------	(a)	(a)	(b)

---

[a] If gross beta concentration exceeds permissible ^{90}Sr level.

[b] Analysis for ^{226}Ra if gross alpha concentration exceeds permissible ^{226}Ra level.

W, Weekly.

Q, Quarterly.

NEW MEXICO

Population: 1,016,000
Area: 121,666 mi^{2}

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
Air	0												
Milk	0												
Miscellaneous	0												
Water:													
General:													
Surface	10	Varies	Varies [a]	------	------	------	------	------	------	------	------	------	^{3}H
Source oriented	0												

---

[a] Analysis conducted by National Environmental Research Center, Las Vegas, Nevada.

NEW YORK

Population: 18,190,700
Area: 49,576 mi^{2}

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
Air													
General	1	Weekly	Weekly	------	------	X	------	------	------	------	------	------	^{85}Kr
Source oriented:													
Consolidated Edison	2	Weekly	Weekly	------	------	X							
Nine Mile Point	1	Weekly	Weekly	------	------	X							
R. E. Ginna	1	Weekly	Weekly	------	------	X							
Nuclear Fuel Services[a]	5	Weekly	Weekly	------	------	X							
	5	Weekly	(c)	------	------	------	------	------	------	------	------	------	(b)
	5	(c)	(c)	------	------	------	------	------	------	------	------	------	(b)
	5	Weekly	Weekly	------	------	------	------	------	------	------	------	------	(d)
Cornell University	1	Weekly	Weekly	------	------	X							
United Nuclear	1	Weekly	Weekly	------	------	X							
Union Carbide	1	Weekly	Weekly	------	------	X							
Milk:													
General	1	Weekly	Weekly	X	------	------	X	X	X	------	(e)	X	(f)
	2	2/month	2/month	X	------	------	X	X	X	------	(e)	X	(f)
	2	Monthly	Monthly	X	------	------	X	X	X	------	X	X	(f) (f)
Source oriented:													
Consolidated Edison	1	Monthly	Monthly	X	------	------	X	X	X	------	------	X	^{3}H(HTO)^{f}
Nine Mile Point	4	Monthly	Monthly	X	------	------	X	X	X	------	------	X	^{3}H(HTO)^{f}
R. E. Ginna	3	Monthly	Monthly	X	------	------	X	X	X	------	------	X	^{3}H(HTO)^{f}
Nuclear Fuel Services[b]	12	Monthly	Monthly	X	------	------	X	X	X	------	X	------	(f)(f)
	1	Weekly	Weekly	(i)	------	------	X	X	X	------	(i)	------	(f)(i)
	8	1/2 months	1/2 months	------	------	------	------	X	X	------	------	------	^{129}I
Union Carbide	1	2/month	2/month	X	------	------	X	X	X	------	------	X	(f)
	1	Planned	Planned										
Brookhaven	3	Monthly	Monthly	X	------	------	X	X	X	------	------	X	^{3}H(HTO)^{f}
Miscellaneous:													
General:													
Fish	1	Semiannually	Semiannually	X	------	------	------	X	X	------	------	(f)	(f)
Fallout	1	Weekly	Weekly	X	------	------	------	X	X	------	X	X	^{3}H(HTO)^{f}

See footnotes at end of table.

166

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
NEW YORK—continued													
Source oriented:													
Consolidated Edison:													
Algae or vegetation	5	Semiannually	Semiannually	X				X	X				(f)
Fish	4	Semiannually	Semiannually	X				X	X			X	(f)
Bottom sediments	4	Semiannually	Semiannually	X				X	X				Pu, IU, [f]
R. E. Ginna:													
Algae or vegetation	2	Semiannually	Semiannually	X				X	X				(f)
Fish	1	Semiannually	Semiannually	X				X	X			X	(f)
Bottom sediments	2	Semiannually	Semiannually	X				X	X				Pu, IU, [f]
Crops	(k)	Semiannually	Semiannually	X				X	X				(f)
Nine Mile Point:													
Algae or vegetation	2	Semiannually	Semiannually	X				X	X				(f)
Fish	1	Semiannually	Semiannually	X				X	X			X	(f)
Bottom sediments	2	Semiannually	Semiannually	X				X	X				Pu, IU, [f]
Crops	(k)	Semiannually	Semiannually	X				X	X				(f)
Shoreham:													
Fish	1	Semiannually	Semiannually	X				X	X				(f)
National Lead:													
Bottom Sediments	1	Semiannually	Semiannually	X				X	X			X	(f)
Nuclear Fuel Services:													
Fish	7	Semiannually	Semiannually	X				X	X			X	Pu, IU, [f]
Crops	(k)	Annually	Annually	X				X	X			X	(f)
Deer	(k)	Semiannually	Semiannually	X				X	X				(f)
Small game	(k)	Continuous during summer	Continuous during summer	X				X	X			X	(f) (l) ^{129}I, [f]
Fallout	1	Weekly	Weekly	X				X	X		X	X	^{3}H(HTO) [f]
Water:													
General:													
Public supply	1	Daily	Monthly composite			X							^{3}H(HTO)
Public supply—surface	1	Daily	Weekly composite			X							^{3}H(HTO) [j]
	2	Weekly	Weekly		X	X							^{3}H(HTO)
	1	Monthly	Monthly			X							
Surface	1	Daily	Weekly composite			X							
	2	Monthly	Monthly			X							^{3}H(HTO)
	2	Monthly	Monthly			X							
	3	2/Year	2/Year			X						X	
Source oriented:													
Consolidated Edison:													
Surface	1	Quarterly	Quarterly			X							
	2	Daily	Weekly composite	X		X		X	X			X	^{3}H(HTO) [f, j]
Public supply:													
Treated	2	Monthly	Monthly			X							
Raw	4	Monthly	Monthly			X							
Nine Mile Point:													
Surface	1	Monthly	Monthly			X							^{3}H(HTO)
Public	1	Continuous	Biweekly			X							^{3}H(HTO) [m]
R. E. Ginna:													
Surface	1	Continuous	Weekly composite			X	X						^{3}H(HTO)
Nuclear Fuel Services: [a]													
Surface	1	Daily	Daily	(n)		X		X	X			(n)	^{3}H(HTO) [f]
	1	Weekly	Weekly		X	X						X	^{129}I, ^{3}H (HTO)
	1	Weekly	Weekly	X	X	X		X	X			X	^{129}I, ^{3}H (HTO) [f]
	1	Weekly	Weekly			X						X	^{129}I, ^{3}H (HTO)
	1	Monthly	Monthly		X	X							^{3}H(HTO)
	1	Monthly	Monthly		X	X						X	^{3}E(HTO)
Public supply:													
Surface	10	Annually	Annually			X							^{3}H(HTO)
Cornell Burial Site:													
Surface	2	2/Year	2/Year			X							^{3}H(HTO)
Well	6	Annually	Annually			X							^{3}H(HTO)
Union Carbide:													
Surface	1	Monthly	Monthly			X	X						^{3}H(HTO)
Pawling													
Surface	1	Monthly	Monthly		X	X							
Knolls Atomic Power Laboratory:													
Surface	1	Monthly	Monthly			X							^{3}H(HTO)
National Lead:													
Surface	1	2/Year	2/Year		X	X							
Shoreham:													
Surface	2	2/Year	2/Year			X				X			^{3}H(HTO)
Brookhaven	1	Monthly	Monthly			X							^{3}H(HTO)

---

[a] Nuclear Fuel Services shut down for an indefinite period.

[b] Plutonium analysis done 13 times per year.

[c] Krypton-85 sample taken at one of the five air stations during a plant dissolution. Site is determined by wind direction.

[d] Iodine-129 by charcoal cartridge is planned.

[e] Strontium-89, iodine-129 and tritium (HTO)-12 analyses per year.

[f] Isotopic gamma normally includes ruthenium plus any other discernible photopeaks.

[g] Strontium-89—12 analyses per year.

[h] Schedule may be reduced until plant goes back into operation.

[i] Iodine-129, tritium—4 analyses per year.

[j] 12 analyses per year.

[k] Around vicinity of installation.

[l] Iodine-129, tritium, plutonium.

[m] 13 analyses per year.

[n] Isotopic gamma and strontium-90 done if gross beta is greater than 300 pCi/liter.

IU, Isotopic uranium.

167

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
NORTH CAROLINA													
Population: 5,082,100 Area: 52,586 mi²													
Air:													
General	1 4	Daily 2/month	Daily 2/month	(a) (c)	------ ------	X X	(a) (c)	(a) X	(a) X	(a) X	 ------	 ------	(a,b) (b)
Source oriented:													
Wm. B. McGuire Nuclear Station	1	2/month	2/month	(c)	------	X	(c)	X	X	X	------	------	(b)
Milk:[d]													
General	6	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Source oriented:													
Wm. B. McGuire Nuclear Station	1	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Miscellaneous													
General:													
Shellfish	1	As available	As collected	X	X	X	X	X	X	X	X	X	(b,e)
Source oriented:													
Nuclear medicine in hospitals Sewage	4	Monthly	Monthly	X									
Water:[f]													
General													
Surface	10	Monthly	Monthly	------	(g)	(g)	------	------	------	------	------	------	(h)
Public supply	10	Monthly	Monthly	------	X	X	------	------	------	------	------	------	(i)
Source oriented:													
Brunswick Nuclear Power Plant: Surface	4	Monthly	Monthly	X	X	X							
Wm. B. McGuire Nuclear Station: Surface	2	Monthly	Monthly	X	X	X							

---

[a] Gamma analysis on each filter exhibiting high gross beta readings.
[b] ^{106}Ru, ^{144}Ce, ^{95}Zr-Nb, ^{65}Zn.
[c] Gamma analysis on at least 1 filter per month.
[d] These are composite samples representing the milk shed for the area.
[e] Upon completion of Brunswick Steam Electric Plant, a regular shellfish sampling program will begin.
[f] The State is carrying out a survey of all public ground water supplies
[g] Gross alpha and beta on suspended and dissolved solids from 5 samples/month. Both analyses done if gross alpha-beta on total solids is high.
[h] If gross beta >5 pCi/liter, gamma spectrum analysis for ^{144}Ce, ^{131}I, ^{106}Ru, ^{137}Cs, ^{95}Zr, ^{95}Nb, ^{54}Mn, ^{65}Zn, ^{40}K, ^{140}Ba; ^{140}La, and radiochemical analysis for ^{89}Sr and ^{90}Sr.
[i] Same as (h) except no radiochemical analysis performed for ^{89}Sr and ^{90}Sr.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
NORTH DAKOTA													
Population: 617,800 Area: 70,665 mi²													
Air:													
General	9 6	30/year 61/year	30/year 61/year	------ ------	------ ------	X X							
Source oriented	0												
Milk:													
General	6	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Source oriented	0												
Miscellaneous	0												
Water	0												

168

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
OHIO													
Population: 10,652,000 **Area: 41,222 mi^2**													
Air	0												
Milk	0												
Miscellaneous	0												
Water:													
General:													
Surface	19	Monthly	Monthly	------	X	X							
Source oriented:													
Plum Brook Reactor:													
Surface	2	Monthly	Monthly	------	X	X							
Ground	1	Monthly	Monthly	------	X	X							
AEC-Feed Materials Production Center:													
Surface	1	Monthly	Monthly	------	X	X							
AEC Monsanto Research Corp:													
Surface	1	Monthly	Monthly	------	X	X							
Goodyear Atomic Corp.:													
Surface	2	Monthly	Monthly	------	X	X							
Battelle Mem. Institute Reactor:													
Surface	1	Monthly	Monthly	------	X	X							
OKLAHOMA													
Population: 2,559,300 **Area: 69,919 mi^2**													
Air:													
General	97	10/month	Weekly	------	------	X							
Source oriented	4	10/month	Monthly	------	------	X							
Milk	0												
Miscellaneous	0												
Water:													
General:													
Ground, surface	597	Once every 3 years	Once every 3 years	------	X	X	------	------	------	------	------	------	^{226}Ra
Surface	32	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{226}Ra
Source oriented:													
Kerr-McGee facilities:													
Surface	11	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{226}Ra
Fansteel facilities:													
Surface	3	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{226}Ra
OREGON													
Population: 2,091,400 **Area: 96,981 mi^2**													
Air:													
General	2	Weekly	Weekly	------	------	X							
Source oriented:													
Trojan	3	Quarterly	Quarterly	------	------	X							
Chem Nuclear (burial grounds)	1	Semiannually	Semiannually	------	------	X							
Nevada Test Site	2	Daily	Daily	------	------	X							
Milk:													
General	6	Monthly	Monthly	X	------	------	X	X	X	X	------	(a)	
Source oriented:													
Trojan	2	Biweekly	Biweekly	X	------	------	X	X	X	X	------	(a)	
	3	Quarterly	Quarterly	X	------	------	X	X	X	X	------	(a)	
Oregon State University reactor	1	Bimonthly	Bimonthly	X	------	------	X	X	X	X	------	(a)	
Miscellaneous:													
General:													
Sediment	12	Semiannually	Seimiannually	X	------	------	------	X	------	X	------	------	(b)
	6	Annually	Annually	X	------	------	------	X	------	X	------	------	(b)
External radiation (TLD)	6	Semiannually	Semiannually	------	------	------	------	------	------	------	------	------	(a)
Source oriented:													
Trojan:													
Sediment	4	Monthly	Monthly	X	------	------	------	X	------	X	------	------	^{65}Zn, [b]
Soil	8	Quarterly	Quarterly	X	------	------	------	X	------	X	------	------	(b)
Vegetation	8	Quarterly	Quarterly	X	------	------	X	X	X	X	------	------	(b)
Algae	2	Monthly when available	Monthly when available	X	------	------	------	X	------	X	------	------	^{65}Zn, [b]
	3	Semiannually	Semiannually	X	------	------	------	------	------	X	------	------	^{65}Zn, [b]
	2	Annually	Annually	X	------	------	------	------	------	X	------	------	^{65}Zn, [b]

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
Oregon—continued													
Shellfish	4	Quarterly when available	Quarterly when available	X						X			^{65}Zn, [d]
	3	Semiannually	Semiannually	X						X			^{65}Zn, [d]
	2	Annually	Annually	X						X			^{65}Zn, [d]
Fish	2	Semiannually	Semiannually	X			X			X			(d)
	4	Annually	Annually	X			X			X			(d)
External radiation (TLD)	12	Quarterly	Quarterly										(c)
Chem Nuclear (burial grounds):													
Soil	3	Semiannually	Semiannually	X				X		X			(b)
Hanford:													
Algae	2	Quarterly when available	Quarterly when available	X				X		X			^{65}Zn, [b]
Natural activity study:													
Sediment [e]	12	Semiannually	Semiannually	X				X		X			(b)
	5	Annually	Annually	X				X		X			(b)
Water:													
General:													
Surface	21	Semiannually	Semiannually		X	X				X			^{3}H, [d]
	11	Annually	Annually	X	X	X				X			^{3}H, [d]
Precipitation	1	Daily when available	Daily when available			X							
	2	Monthly	Monthly	X	X	X				X			^{3}H, [d]
Interstate carriers	10	Annually	Annually	X	X	X				X			^{3}H, [d]
Source oriented:													
Trojan:													
Surface	4	Monthly	Monthly	X	X	X				X			^{65}Zn, ^{3}H, [d]
Ground	1	Quarterly	Quarterly	X	X	X				X			^{65}Zn, ^{3}H, [d]
Precipitation	3	Quarterly	Quarterly	X	X	X				X			^{3}H, [d]
Hanford:													
Surface	4	Quarterly	Quarterly	X	X	X				X			^{65}Zn, ^{3}H, [d]
Natural activity study:													
Ground	22	Semiannually	Semiannually	X	X	X				X			^{3}H, [d]

[a] Analyzed quarterly.
[b] ^{103,106}Ru, ^{95}Zr-Nb, ^{60}Co.
[c] Integrated dose.
[d] ^{103,106}Ru, ^{95}Zr-Nb.
[e] Natural activity study for radium, uranium and thorium.

PENNSYLVANIA

Population: 11,793,900
Area: 45,333 mi^2

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
Air:													
General	0												
Source oriented:													
Peach Bottom:													
Onsite particulate filters	1	Quarterly	Quarterly		X	X						X	
Offsite particulate filters	1	Weekly	Weekly		X	X						X	
Three Mile Island:													
Offsite particulate filters	1	Weekly	Weekly		X	X						X	
Milk:													
General	4	Monthly	Monthly				X	X	X	X		X	
Source oriented:													
Peach Bottom	1	Quarterly	Quarterly	X			X	X	X	X		X	
Three Mile Island	1	Quarterly	Quarterly	X			X	X	X	X		X	
Miscellaneous:													
General	0												
Source oriented:													
Peach Bottom:													
External radiation (TLD)	6	Quarterly	Quarterly										Readout
Three Mile Island:													
External radiation (TLD)	6	Quarterly	Quarterly										Readout
Saxton Nuclear Reactor:													
External radiation (TLD)	6	Quarterly	Quarterly										Readout
Source oriented:													
NUMEC Uranium:													
Silt	1	Sporadic	Sporadic	X	X	X							U
Molybdenum Corp.:													
Slag	1	Sporadic	Sporadic	X	X	X							Th
Vitro Metals(uranium burials):													
Silt	1												U
Martin Marietta (SNAP Generator):													
Soil, bones, vegetation	1	Sporadic	Sporadic									X	

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
PENNSYLVANIA—continued													
Water:													
General:													
Surface	30	Quarterly	Quarterly	------	X	X	------	------	------	------	------	------	^{3}H
Source oriented:													
Peachbottom:													
Onsite	2	Quarterly	Quarterly	X	X	X	X	X	------	------	------	X	^{3}H
Offsite	2	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{3}H
Three Mile Island:													
Onsite	1	Quarterly	Quarterly	------	X	X	------	------	------	------	------	------	^{3}H
Offsite	3	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{3}H
Saxton Nuclear Reactor:													
Onsite	2	Quarterly	Quarterly	X	X	X	X	X	------	------	------	X	^{3}H
Offsite	2	Monthly	Monthly	------	X	X	------	------	------	------	------	------	^{3}H
NUMEC Uranium:													
Surface	6	Quarterly	Quarterly	------	X	X							
Shippingport:													
Surface	2	Quarterly	Quarterly	------	X	X							
Westinghouse:													
Surface	6	Quarterly	Quarterly	------	X	X							
Bettis Labs:													
Surface	2	Quarterly	Quarterly	------	X	X							

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
PUERTO RICO													
Population: 2,689,900 Area: 3,435 mi^{2}													
Air:													
General	0												
Source oriented:													
Reactor oriented	2	3/week	3/week	------	------	X							
Milk:													
General	0												
Source oriented:[a]													
Pasteurized	4	Weekly	Weekly	------	------	------	X	X	X	X	M	M	
Raw	4	Weekly	Weekly	------	------	------	X	X	X	X	M	M	
Miscellaneous:													
General	0												
Source oriented:													
Reactor source:													
Mixed leaves, sugar cane leaves	2	Weekly	Weekly	------	------	X	X	X	X	X	------	------	(b)
Water:													
General	0												
Source oriented:[a]													
Reactor oriented:													
Public supply	4	Monthly	Monthly	------	------	X	X	X	X	X	------	------	(b)
Precipitation	1	Monthly	Monthly	------	------	X	X	X	X	X	------	------	(b)

[a] Source and fallout oriented.

[b] ^{144}Ce, ^{106}Ru, ^{95}Zr, ^{65}Zn.

M, monthly.

171

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
RHODE ISLAND													
Population: 949,700 **Area: 1,214 mi^2**													
Air:													
General	0												
Source oriented:													
United Nuclear Corp.	2	Weekly	Weekly	------	X								
Nuclear Research Reactor	2	Weekly	Weekly	X	------	X	X	X	X	X	------	------	(^{a})
Nuclear Submarine Base	2	Weekly	Weekly	X	------	X	X	X	X	X	------	------	(^{a})
Milk	0												
Miscellaneous:													
General	0												
Source oriented:													
United Nuclear Corp.:													
Soil and vegetation	2	Sporadic	Sporadic	X	------	------	X	X	X	X	------	------	(^{b})
Nuclear Research Reactor:													
Soil and vegetation	2	Sporadic	Sporadic	X	------	------	X	X	X	X	------	------	(^{b})
Nuclear Submarine Provision Commissary:													
Soil and vegetation	2	Sporadic	Sporadic	X	------	------	X	X	X	X	------	------	(^{b})
Proposed Rome Point Nuclear Power Reactor:													
Soil and vegetation	2	Sporadic	Sporadic	X	------	------	X	X	X	X	------	------	(^{a})
Water:													
General	0												
Source oriented:													
United Nuclear Corp.:													
Surface	2	Monthly	Monthly	------	------	------	X	X	X	X	------	------	(^{b})
Nuclear Research Reactor:													
Surface	2	Monthly	Monthly	------	------	------	X	X	X	X	------	------	(^{b})
Nuclear Submarine Base:													
Surface	2	Monthly	Monthly	------	------	------	X	X	X	X	------	------	(^{b})
Proposed Rome Point Nuclear Power Reactor:													
Surface	2	Weekly	Weekly	------	------	------	X	X	X	X	------	------	(^{b})

[a] ^{144}Ce, ^{106}Ru, ^{54}Mn, ^{125}Sb, ^{65}Zn, ^{60}Co.

[b] ^{144}Ce, ^{106}Ru, ^{54}Mn, ^{95}Zr, ^{65}Zn, ^{60}Co.

172

Table 1. Summary of State environmental surveillance programs, 1972—continue

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
SOUTH CAROLINA													
Population: 2,590,500 Area: 31,055 mi^2													
Air:													
General	12	Weekly	Weekly	X	X	X							
Source oriented	3	Weekly	Weekly	X	X	X	X					X	
Milk:													
General	0												
Source oriented:													
Allied-Gulf Nuclear Services	2	Quarterly	Quarterly	X			X	X	X	X	X	X	
H.B. Robinson Nuclear Power Plant	3	Quarterly	Quarterly	X			X	X	X	X	X	X	
Oconee Nuclear Station	3	Quarterly	Quarterly	X			X	X	X	X	X	X	
Virgil C. Summer Nuclear Station	3	Quarterly	Quarterly	X			X	X	X	X	X	X	
Miscellaneous:													
General	0												
Source oriented:													
H.B. Robinson Nuclear Power Plant:													
Soil	4	Quarterly	Quarterly	X									
Silt	2	Quarterly	Quarterly		X	X							
External radiation (TLD)	10	Quarterly	Quarterly										(a)
Vegetation	4	Quarterly	Quarterly	X	X	X							
Marine life	2	Quarterly	Quarterly	X	X	X							
Westinghouse Fuel Fabrication Plant:													
Mud	1	Biannually	Biannually										(b)
External radiation (TLD)	1	Quarterly	Quarterly										(a)
Chem-Nuclear Services site near Barnwell, S.C.:													
Soil	4	Quarterly	Quarterly	X									
External radiation (TLD)	4	Quarterly	Quarterly										(a)
Savannah River Plant:													
Marine life	3	Biannually	Biannually	X				X					
Allied-Gulf Nuclear Services:													
Soil	8	Quarterly	Quarterly	X									
External radiation (TLD)	4	Quarterly	Quarterly										(a)
Vegetation	5	Seasonal	Seasonal	X									
Marine life	2	Biannually	Biannually	X				X					
Water:													
General	0												
Source oriented:													
H.B. Robinson Nuclear Power Plant:													
Surface	15	Weekly	Weekly	X	X	X							^{b}H
Ground-public supply	9	Monthly	Monthly	X	X	X							^{b}H
Westinghouse:													
Surface	3	Monthly	Monthly		X	X							
	9	Biannually	Biannually		X	X							
External radiation (TLD)	1	Quarterly	Quarterly										(a)
Chem-Nuclear Services site near Barnwell, S.C.													
Surface	1	Monthly	Monthly	X	X	X							
Ground	3	Quarterly	Quarterly	X	X	X							
	3	Monthly	Monthly	X	X	X							
Surface-public supply	2	Monthly	Monthly	X	X	X							^{b}H
Savannah River Plant:													
Surface	2	Quarterly	Quarterly	X	X	X							(b)
	3	Monthly	Monthly	X	X	X							(b)
	2	Weekly	Weekly	X	X	X							
Surface (raw)	2	Monthly	Monthly		X	X							^{b}H
Allied-Gulf Nuclear Services:													
Surface	5	Monthly	Monthly	X	X	X							^{b}H
	6	Quarterly	Quarterly	X	X	X							^{b}H
Ground-well	2	Quarterly	Quarterly	X	X	X							^{b}H
Public supply-well	2	Monthly	Monthly	X	X	X							^{b}H
Wm. B. McGuire Nuclear Station:													
Surface	3	Quarterly	Quarterly	X	X	X							
Public supply	2	Quarterly	Quarterly	X	X	X							
Oconee Nuclear Station:													
Surface	4	Monthly	Monthly	X	X	X							
Public supply	4	Quarterly	Quarterly	X	X	X							^{b}H
Virgil C. Summer Nuclear Station:													
Surface	2	Quarterly	Quarterly	X	X	X							
Public supply	4	Quarterly	Quarterly	X	X	X							

---

[a] Direct radiation

[b] Special nuclides.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
SOUTH DAKOTA													
Population: 666,300 Area: 77,047 mi^2													
Air	0												
Milk	0												
Miscellaneous	0												
Water	0												
TENNESSEE													
Population: 3,924,200 Area: 42,246 mi^2													
Air	0												
Milk:													
General:													
Pasteurized	1	2/month	2/month	------	------	------	X	X	X	X	X	X	
Source oriented:													
Oak Ridge:													
Pasteurized	2	2/month	2/month	------	------	------	X	X	X	X	X	X	
Browns Ferry:													
Pasteurized	1	2/month	2/month	------	------	------	X	X	X	X	X	X	
Sequoyah Nuclear Plant	[a] 1	Monthly	Monthly	------	------	------	X	X	X	X	X	X	
Miscellaneous:													
General	0												
Source oriented:													
American Nuclear Corp:													
Soil	1	5/week	Monthly	X	------	------	------	X	------	------	------	------	[b]
Water:													
General:													
Surface	4	Daily	Monthly	------	X	X							
	1	Monthly	Monthly	------	X	X							
Source oriented:													
Oak Ridge:													
Surface	1	Monthly	Monthly	------	X	X							
	1	Daily	Monthly	------	X	X							
Sequoyah Nuclear Plant:													
Surface	2	Monthly	Monthly	------	X	X							
Public supply	1	Monthly	Monthly	------	X	X							
American Nuclear Corp:													
Surface	1	Weekly	Weekly	------	X	X	------	------	------	------	------	------	[b]
Public supply	1	Daily	Monthly	X	X	X	------	------	------	------	------	------	^{60}Co
Ground	1	Weekly	Weekly	------	X	X	------	------	------	------	------	------	[b]
W. R. Grace Co:													
Surface	4	Monthly	Monthly	------	X	X							
	1	Daily	Monthly	------	X	X							
Nuclear Fuel Services:													
Surface	2	Monthly	Monthly	------	X	X							
	1	Daily	Monthly	------	X	X							

[a] Split, with Eastern Environmental Radiation Facility, Montgomery, Ala.

[b] XY plot comparison for ^{60}Co–^{137}Cs.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
TEXAS													
Population: 11,196,700 Area: 267,339 mi^2													
Air:													
General	5	Daily	Daily	------	------	X							
Source oriented	0												
Milk:													
General	12	4 /year	4 /year	X	------	------	X	X	X	X	([a])	X	
	1	Monthly	Monthly	X	------	------	X	X	X	X	([a])	X	
Source oriented:													
Texas A & M	1	Monthly	Monthly	X	------	------	X	X	X	X	([a])	X	
Miscellaneous:													
General:													
Mud, silt, dirt	1	2 /year	2 /year	X	X	X							
Oysters	4	2 /year	2 /year	X	X	X							
Source oriented:													
Texas A & M:													
Mud, dirt	4	2 /year	2 /year	X	X	X							
Vegetation	2	3 /year	3 /year	X	X	X							
Todd Shipyards:													
Mud, dirt	2	1 /year	1 /year	X	X	X							
Oysters	2	2–6 /year	2–6 /year	X	X	X							
Houston:													
Mud, dirt	20	2 /year	2 /year	X	X	X							
Vegetation	2	2 /year	2 /year	X	X	X							
Uranium Dist:													
Mud, dirt	8	3 /year	3 /year	X	X	X							
Oysters	2	2 /year	2 /year	X	X	X							
Pantex:													
Mud, dirt	2	2 /year	2 /year	X	X	X							
Water:													
General:													
Surface	2	4 /year	4 /year	X	X	X							
Source oriented:													
Texas A & M:													
Surface	3	20–30 /year	20–30 /year	X	X	X							
	2	4–6 /year	4–6 /year	X	X	X							
Todd Shipyards:													
Sea	3	2 /month	2 /month	X	------	X							
University of Texas:													
Surface	4	4 /year	4 /year	X	X	X							
Uranium Dist:													
Surface	6	1 /month	1 /month	X	X	X	------	------	------	------	------	------	^{226}Ra, ^{238}U
	10	6 /year	6 /year	X	X	X	------	------	------	------	------	------	^{226}Ra, ^{238}U
Municipal drinking	30	2 /year	2 /year	X	X	X	------	------	------	------	------	------	^{226}Ra, ^{238}U[a]
Private drinking	50	1–2 /year	1–2 /year	X	X	X	------	------	------	------	------	------	^{226}Ra, ^{238}U[a]

[a] When indicated.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
UTAH													
Population: 1,059,300 Area: 84,916 mi^2													
Air:													
General	0												
Source oriented:													
Nevada Test Site	18	Daily	Daily	------	------	X							
Milk:													
General	0												
Source oriented:													
Nevada Test Site	17	Biweekly,[a]	Biweekly,[a]	------	------	------	X	X	X	X	X	X	
Miscellaneous	0												
Water:													
General	0												
Source oriented:													
Waste water treatment plants:													
Surface [b]	48	4 /year	4 /year	------	X	X	------	------	------	------	------	------	^{3}H,[c]
Effluent	1	4 /year	4 /year	------	X	X							

[a] When a test—atmospheric or underground—takes place, samples are collected daily until level of contamination is established.

[b] Waste water treatment plant outfall-all samples taken above outfall.

[c] To establish a baseline for the analysis of ^{3}H in the environment.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
VERMONT													
Population: 444,700 Area: 9,609 mi^2													
Air:													
General	2	Weekly	Weekly	(^{a})	X	X							
Source oriented:													
Vermont Yankee	6	Weekly	Weekly	(^{a})	X	X							
Milk:													
General	0												
Source oriented:													
Vermont Yankee	4	Monthly	Monthly	X	......	......	X	X	X	X	......	X	
Miscellaneous:													
General:													
External radiation (TLD)	2	Monthly	Monthly	......	......	......	......	......	......	......	......	......	(^{b})
	2	Semiannually	Semiannually	......	......	......	......	......	......	......	......	......	(^{b})
Source oriented:													
Vermont Yankee:													
External radiation (TLD)	11	Monthly	Monthly	......	......	......	......	......	......	......	......	......	(^{b})
	6	Semiannually	Semiannually	......	......	......	......	......	......	......	......	......	(^{b})
Clams, mud, etc.	1	Annually	Annually	X	X	X							
Grass, maple sap	1	Annually	Annually	X	X	X							
Fish	5	Semiannually	Semiannually	X	X	X							
Local crops, eggs	2	Annually	Annually	X	X	X							
Mushrooms	3	Semiannually	Semiannually	X									
Water:													
General	0												
Source oriented:													
Vermont Yankee: ^{c}													
Surface	2	Monthly	Monthly	(^{a})	X	X							
Ground	3	Monthly	Monthly	(^{a})	X	X							
Public supply	1	Monthly	Monthly	(^{a})	X	X							

---

[a] Quarterly composite (scans of air filters are qualitative only).
[b] Direct radiation.
[c] Random—approximately 40 private water supplies have been sampled' All supplies will be sampled again about 6 months following startup.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
VIRGINIA													
Population: 4,648,500 Area: 40,817 mi^2													
Air	0												
Milk:													
General:													
Pasteurized	4	Monthly	Monthly	......	......	......	X	X	X	X	X	X	
Source oriented:													
Surry Reactor:													
Raw	3	Monthly	Monthly	......	......	......	X	X	X	X	X	X	
Miscellaneous:													
General:													
Oysters	3	Semiannually	Semiannually	X	......	X	X	X	X	X	......	......	(^{a})
Silt	4	Semimonthly	Semimonthly	X	......	X	X	X	X	X	......	......	(^{a})
Source oriented:													
Surry Reactor:													
Oysters	6	Monthly	Monthly	X	......	X	X	X	X	X	......	......	(^{a})
Rangia	3	Monthly	Monthly	X	......	X	X	X	X	X	......	......	(^{a})
Silt	6	Monthly	Monthly	X	......	X	X	X	X	X	......	......	(^{a})
Navy Yard:													
Oysters	1	Monthly	Monthly	X	......	X	X	X	X	X	......	......	(^{a})
D & S Piers:													
Oysters	1	Monthly	Monthly	X	......	X	X	X	X	X	......	......	(^{a})
NNSBDD Company:													
Silt	2	Monthly	Monthly	X	......	X	X	X	X	X			
Water:													
General:													
Surface	3	Semiannually	Semiannually	X	......	X	X	X	X	X	X	X	^{54}Mn, ^{a}
	4	Monthly	Monthly	X	......	X	X	X	......	X	X	X	(^{b})
	1	Semiannually	Semiannually	X	......	X	X	X	......	X	X	X	(^{b})
Public supply	(^{c})	3/month	3/month	......	......	X							
Ground	(^{c})	As available	As available	......	......	X							
Source oriented:													
Surry Reactor:													
Surface	9	Monthly	Monthly	......	......	X	X	X	X	X	X	X	(^{a})
Navy Yard:													
Surface	1	Monthly	Monthly	......	......	X	X	X	X	X	X	X	(^{a})
D & S Piers:													
Surface	1	Monthly	Monthly	......	......	X	X	X	X	X	X	X	(^{a})

---

[a] ^{106}Ru-Rh, ^{65}Zn, ^{95}Zr-Nb.
[b] ^{106}Ru-Rh, ^{95}Zr-Nb.
[c] Varies statewide.
NNSBDD Co., Newport News Shipbuilding and Dry Dock Co.

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	Analysis									
				γ scan	Gross		^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
					α	β							
WASHINGTON													
Population: 3,409,200 **Area: 68,192 mi^2**													
Air	0												
Milk:													
General	2	Monthly	Monthly				X	X	X	X		X	^{65}Zn
Source oriented:													
Hanford	2	Bimonthly	Bimonthly				X	X	X	X		X	^{65}Zn
Miscellaneous:													
General	0												
Source oriented:													
Hanford:													
Shellfish	1	Bimonthly	Bimonthly							X			([a])
Nuclear ships:													
Shellfish	1	Annually	Annually							X			([a])
Sediment	2	Annually	Annually	X		X				X			
Water:													
General:													
Surface	4	Monthly	Monthly			X							
Source oriented:													
Hanford:													
Surface	1	Weekly	Weekly			X							^{46}Sc, ^{51}Cr,[a]
	1	Monthly	Monthly			X							^{46}Sc, ^{51}Cr,[a]
Nuclear ships:													
Surface, salt water	1	Semiannually	Semiannually	X		X							

[a] ^{65}Zn, ^{95}Zr, ^{106}Ru, ^{32}P.

WEST VIRGINIA													
Population: 1,744,200 **Area: 24,181 mi^2**													
Air	0												
Milk:													
General	1	Monthly	Monthly				X	X	X	X			
	1	Quarterly	Quarterly								X	X	
Source oriented	0												
Miscellaneous	0												
Water:													
General:													
Interstate carriers	12	Annually	Annually		X	X							
Potable public water supplies	139	Once/3 years	Once/3 years		X	X							
Source oriented	0												

Table 1. Summary of State environmental surveillance programs, 1972—continued

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
WISCONSIN													
Population: 4,417,900 Area: 56,154 mi²													
Air:													
General	1	5/week	5/week			X							
	3	Weekly	Monthly	X		(a)		X					
Source oriented:													
Genoa	2	Weekly	Monthly	X		(a)		X					
Point Beach—Kewaunee	4	Weekly	Monthly	X		(a)		X					
Prairie Island	3	Weekly	Monthly	X		(a)		X					
Milk:													
General	6	Weekly	Weekly				X	X	X	X		(b)	
Source oriented:													
Genoa	1	Monthly	Monthly				X	X	X	X		X	
Point Beach—Kewaunee	1	Monthly	Monthly				X	X	X	X		X	
Prairie Island	1	Monthly	Monthly				X	X	X	X		X	
Miscellaneous:													
General:													
Silt	2	Semiannually	Semiannually		X	X							
Soil	3	Semiannually	Semiannually		X	X							
Source oriented:													
Genoa:													
Silt	4	Semiannually	Semiannually		X	X							
Soil	8	Semiannually	Semiannually		X	X							
Vegetation	8	Semiannually	Semiannually		X	X							
Point Beach—Kewaunee:													
Soil	11	Semiannually	Semiannually		X	X							
Vegetation	11	Semiannually	Semiannually		X	X							
Algae	1	Semiannually	Semiannually		X	X							
Prairie Island:													
Silt	2	Semiannually	Semiannually		X	X							
Soil	6	Semiannually	Semiannually		X	X							
Vegetation	6	Semiannually	Semiannually		X	X							
Water:													
General:													
Surface	10	Monthly	Monthly		X	X							
Precipitation	4	(c)	(c)			X							
Source oriented:													
Genoa:													
Surface	5	Monthly	Monthly		X	X						X	
	2	Semiannually	Semiannually		X	X		X					
Precipitation	1	(c)	(c)			X							
Ground	3	Semiannually	Semiannually		X	X							
Point Beach—Kewaunee:													
Surface	5	Semiannually	Semiannually		X	X		X				X	
Precipitation	4	(c)	(c)			X							
Ground	6	Semiannually	Semiannually		X	X							
Prairie Island:													
Surface	5	Semiannually	Semiannually		X	X		X				X	
Precipitation	3	(c)	(c)			X							
Ground	3	Semiannually	Semiannually[c]		X	X							

[a] Weekly.
[b] Monthly.
[c] Ater each rain greater than 0.1 inch.

State, media, and site	Number of sites	Collection frequency	Analysis frequency	γ scan	Gross α	Gross β	^{131}I	^{137}Cs	^{140}Ba	^{40}K	^{89}Sr	^{90}Sr	Other
WYOMING													
Population: 332,400 Area: 97,914 mi²													
Air	0												
Milk	0												
Miscellaneous	0												
Water:													
General:													
Surface	28	Quarterly	Quarterly		X	X							
Source oriented:													
Shirley Uranium:													
Surface	3	Quarterly	Quarterly		X	X							

SECTION I. MILK AND FOOD

Milk Surveillance, November 1972

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

179

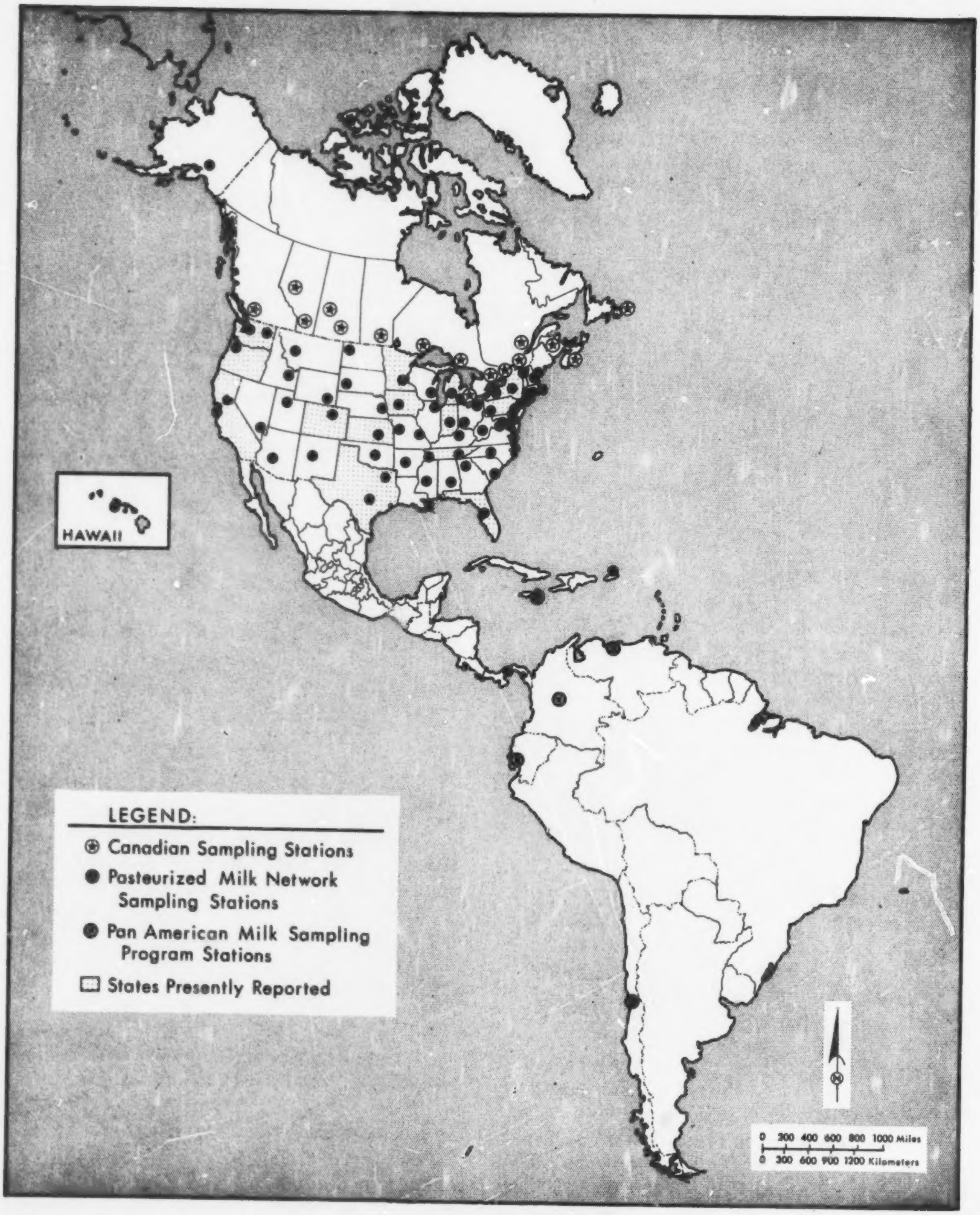
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
● Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000 Miles
0 300 600 900 1200 Kilometers

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2-standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during July 1971 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 14 participated in the study.

The accuracy results of this study for these 14 laboratories are shown in table 1. Considerable improvement has been made in the accuracy of the analyses of all radionuclides compared to the results of previous studies. Some improvement is still needed in the technique for determining the strontium-90 results. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (69 pCi/liter)	13 (100%)	0	0	13	6
Cesium-137 (52 pCi/liter)	12 (92%)	1 (8%)	0	13	6
Strontium-89 (31 pCi/liter)	9 (90%)	1 (10%)	0	10	6
Strontium-90 (41.6 pCi/liter)	9 (69%)	1 (8%)	3 (23%)	13	2.4

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧ 20 pCi/liter;
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number

182

Table 2. Concentrations of radionuclides in milk for November 1972 and 12-month period, December 1971 through November 1972

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	6	0	6
Alaska:	Palmer [c]	P	4	5	0	7
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	12	11	0	5
Calif:	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	1	0	0
	Del Norte	P	9	12	8	10
	Fresno	P	0	1	4	4
	Humboldt	P	3	4	3	7
	Los Angeles	P	2	2	3	4
	Mendocino	P	2	5	3	5
	Sacramento	P	2	2	7	5
	San Diego	P	0	1	0	4
	Santa Clara	P	0	1	0	5
	Shasta	P	2	2	5	6
	Sonoma	P	2	2	0	5
Colo:	Denver [c]	P	NA	4	0	3
	East	R	NS	NA	NS	0
	Northeast	R	NS	NA	NS	0
	Northwest	R	NS	NA	NS	0
	South Central	R	NS	NA	NS	0
	Southeast	R	NS	NA	NS	0
	Southwest	R	NS	NA	NS	0
	West	R	NS	NA	NS	4
Conn:	Hartford [c]	P	NA	5	0	7
	Central	P	6	7	11	13
Del:	Wilmington [c]	P	NA	9	0	8
D.C:	Washington [c]	P	NA	7	6 (2)	6
Fla:	Tampa [c]	P	5	5	38	37
	Central	R	2	5	52	42
	North	R	8	6	17	17
	Northeast	R	4	5	32	30
	Southeast	R	4	5	45	53
	Tampa Bay area	P	4	5	38	37
	West	R	6	8	11	15
Ga:	Atlanta [c]	P	NA	9	0	0
Hawaii:	Honolulu [c]	P	4	2	0	1
Idaho:	Idaho Falls [c]	P	4	4	0	0
Ill:	Chicago [c]	P	5	5	13	10
Ind:	Indianapolis [c]	P	NA	6	13	3
	Central	P	7	7	10	10
	Northeast	P	7	6	15	11
	Northwest	P	9	8	0	12
	Southeast	P	9	8	0	10
	Southwest	P	4	8	10	11
Iowa:	Des Moines [c]	P	NA	4	0	0
	Iowa City	P	6	7	0	7
	Des Moines	P	5	6	0 (3)	6
	Little Cedar	P	8	5	0	9
	Spencer	P	NS	7	NS	13
Kans:	Wichita [c]	P	NA	7	0	0
	Coffeyville	P	NA	8	0	10
	Dodge City	R	NA	5	0	8
	Falls City, Nebr	P	NA	3	0	8
	Hays	P	NA	9	0	7
	Kansas City	P	NA	8	0	9
	Topeka	P	NA	7	0	8
	Wichita	P	NA	8	0	6
Ky:	Louisville [c]	P	NA	7	0	5
La:	New Orleans [c]	P	10	13	0	4
Maine:	Portland [c]	P	NA	6	27	22
Md:	Baltimore [c]	P	NA	7	0	6
Mass:	Boston [c]	P	7	7	13	13
Mich:	Detroit [c]	P	NA	6	0	8
	Grand Rapids [c]	P	NA	8	0	7
	Bay City	P	4	5	0 (2)	9
	Charlevoix	P	0	6	6 (4)	10
	Detroit	P	3	4	0	9
	Grand Rapids	P	0	4	15	8
	Lansing	P	3	5	0 (2)	9
	Marquette	P	3	5	8 (2)	20
	Monroe	P	0	2	0 (2)	4
	South Haven	P	4	7	7 (4)	8
Minn:	Minneapolis [c]	P	NA	7	17	16
	Bemidji	P	10	11	25	19
	Duluth	P	17	21	19	26
	Fergus Falls	P	7	7	10	15
	Little Falls	P	NS	18	NS	41
	Mankato	P	6	10	17	11
	Marshall	P	6	5	18	15

See footnotes at end of table.

183

Table 2. Concentrations of radionuclides in milk for November 1972 and 12-month period, December 1971 through November 1972—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—Continued						
Minn:	Minneapolis	P	9	11	18	15
	Rochester	P	8	7	5	11
Miss:	Jackson [c]	P	NA	9	13	8
Mo:	Kansas City [c]	P	NA	5	0	3
	St. Louis [c]	P	NA	6	0	8
Mont:	Helena [c]	P	NA	4	0	8
Nebr:	Omaha [c]	P	NA	6	0	1
Nev:	Las Vegas [c]	P	NA	1	0	0
N.H:	Manchester [c]	P	NA	8	0	16
N.J:	Trenton [c]	P	NA	7	0	5
N. Mex:	Albuquerque [c]	P	NA	1	0	0
N.Y:	Buffalo [c]	P	4	5	0	5
	New York City [c]	P	NA	8	0	8
	Syracuse [c]	P	NA	6	0	7
	Albany	P	4	6	0	0
	Buffalo	P	5	7	0	0
	Massena	P	5	7	0	0
	New York City	P	NS	NS	NS	NS
	Syracuse	P	8	5	0	0
N.C:	Charlotte [c]	P	NA	9	11	7
N. Dak:	Minot [c]	P	NA	9	0	7
Ohio:	Cincinnati [c]	P	NA	6	13	4
	Cleveland [c]	P	NA	7	0	7
Okla:	Oklahoma City [c]	P	NA	5	0	3
Oreg:	Portland [c]	P	5	5	0	3
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	R	NA		NA	
Pa:	Philadelphia [c]	P	NA	6	0	3
	Pittsburgh [c]	P	NA	9	0	6
	Dauphin	P	0	5	0	11
	Erie	P	6	8	0	11
	Philadelphia	P	6	5	0	7
	Pittsburgh	P	7	7	0	13
R.I:	Providence [c]	P	NA	6	0	10
S.C:	Charleston [c]	P	9	8	18	14
S. Dak:	Rapid City [c]	P	NA	7	0	3
Tenn:	Chattanooga [c]	P	NA	8	11	8
	Memphis [c]	P	NA	7	0	2
	Chattanooga	P	6	10	11	10
	Clinton	R	8	10	16	14
	Fayetteville	R	9	10	12	6
	Kingston	P	10	10	10	7
	Knoxville	P	7	8	11	7
	Lawrenceburg	R	NS	8	NS	9
	Nashville	P	5	8	15	7
	Pulaski	R	5	6	15	8
	Sequoyah	R	8	7	0	17
Tex:	Austin [c]	P	NA	2	0	0
	Dallas [c]	P	NA	6	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	3	3	0	3
Vt:	Burlington [c]	P	NA	6	13	10
Va:	Norfolk [c]	P	NA	6	0	7
Wash:	Seattle [c]	P	NA	3	0	2
	Spokane [c]	P	NA	4	0	6
	Benton County	R	0	1	0	0
	Franklin County	R	NS	1	NS	0
	Longview	R	4		0	
	Sandpoint, Idaho	R	4	9	0	12
	Skagit County	R	7	7	12	4
W. Va:	Charleston [c]	P	NA	8	11	5
Wisc:	Milwaukee [c]	P	NA	5	7 (2)	7
Wyo:	Laramie [c]	P	NA	3	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for November 1972 and 12-month period, December 1971 through November 1972—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		9	17
Edmonton	P	NA		9	26
British Columbia:					
Vancouver	P	NA		21	21
Manitoba:					
Winnipeg	P	NA		10	18
New Brunswick:					
Moncton	P	NA		9	9
Newfoundland:					
St. John's	P	NA		11	24
Nova Scotia:					
Halifax	P	NA		7	17
Ontario: Ottawa	P	NA		8	9
Sault Ste. Marie	P	NA		14	23
Thunder Bay	P	NA		19	22
Toronto	P	NA		7	8
Windsor	P	NA		4	8
Quebec: Montreal	P	NA		5	12
Quebec	P	NA		17	22
Saskatchewan:					
Regina	P	NA		5	14
Saskatoon	P	NA		4	13
CENTRAL AND SOUTH AMERICA:					
Canal Zone:					
Cristobal [c]	P	NA	1	0	9
Chile: Santiago	P	0	1	0	1
Colombia:					
Bogota	P	NS	0	NS	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Mandeville	P	2	3	28	45
Puerto Rico:					
San Juan [c]	P	NS	1	NS	3
Venezuela:					
Caracas	P	0	0	0	0
PMN network average [e]		6	6	4	6

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Cesium-137: Colorado—25 pCi/liter
Oregon —15 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for November 1972 and the 12-month period, December 1971 to November 1972. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for November 1972 were below the respective practical reporting levels. Strontium-89 results for individual samples were all below the practical reporting level with the following exception: New York, Massena (State), 8 pCi/liter.

Strontium-90 monthly averages ranged from 0 to 17 pCi/liter in the United States for November 1972, and the highest 12-month average was 21 pCi/liter (Duluth, Minn.), representing 10.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 52 pCi/liter in the United States for November 1972, and the highest 12-month average was 53 pCi/liter (Southeast Florida), representing 1.5 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

Table 3 gives additions and table 4, corrections for various States and months.

Table 3. Additions to table 2 for January, February, March, June and September 1972

State	January				February			
	Strontium-90		Cesium-137		Strontium-90		Cesium-137	
	Monthly average	12-month average	Monthly average	12-month average	Monthly average	12-month average	Monthly average	12-month average
Oregon:[a]								
Baker	2	2	0	2	NA		0	2
Coos Bay	3	4	8	7	NA		0	7
Eugene	2	2	0	3	NA		0	3
Medford	2	2	14	5	NA		0	5
Portland composite	1	5	22	8	NA		0	9
Portland local	6	5	22	11	NA		0	11
Redmond	2	3	0	2	NA		0	2
Tillamook	3	4	0	0	NA		18	13
	March				September			
Oregon:[a]								
Baker	NA		0	0	NA	2	12	1
Coos Bay	NA		0	5	NA	4	21	3
Eugene	NA		0	3	NA	1	0	1
Medford	NA		0	4	NA	1	17	4
Portland composite	NA		0	9	NA	4	15	7
Portland local	NA		26	12	NA	7	14	6
Redmond	NA		0	2	NA	2	9	1
Tillamook	NA		0	13	NA	6	8	12
	June				September			
Iowa:[a]								
Iowa City	7	7	11	11	7	7	0	8
Des Moines	6	6	10	10	6	6	0	8
Spencer	NS	6	NS	11	NS	6	NS	10
Little Cedar	6	7	11	12	NS	7	NS	11

[a] State samples.

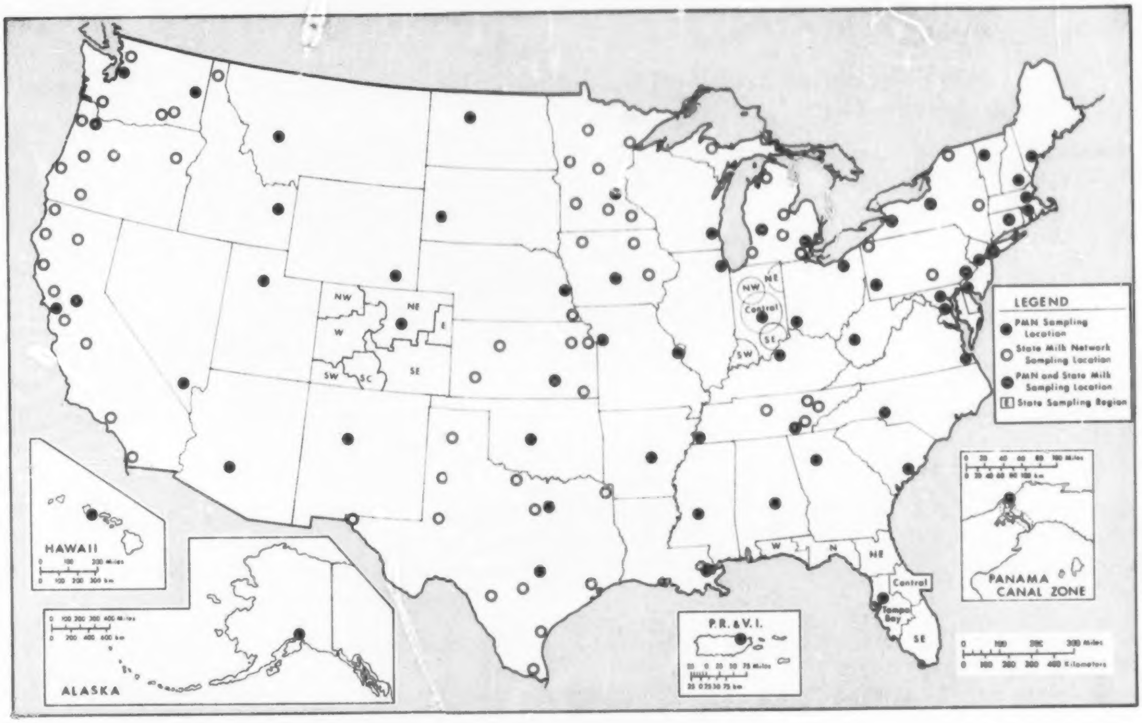
LEGEND
PMN Sampling Location
State Milk Network Sampling Location
PMN and State Milk Sampling Location
E State Sampling Region
NW
NE
W
E
SW
SC
SE
Central
N
Tampa Bay
HAWAII
ALASKA
P.R.& V.I.
PANAMA CANAL ZONE

Figure 2. State and PMN milk sampling stations in the United States

Table 4. Corrections to table 2 for January, February, and March 1972

State	Strontium-90		Iodine-131		Cesium-137		Barium-140	
	Monthly average	12-month average	Monthly average	12-month average	Monthly average	12-month average	Monthly average	12-month average
January 1972								
Kansas:[a]								
Dodge City	4	6	0	2	14	8	0	3
Falls City	7	4	31	5	14	7	11	1
Hays	8	9	0	2	0	10	0	3
Kansas City	7	9	0	4	0	14	0	2
Topeka	6	8	0	3	0	9	0	4
Wichita	7	10	0	4	14	11	0	3
Colorado:[a]								
East			[b]29 (2)					
Northeast			37 (6)					
February 1972								
Kansas:[a]								
Dodge City			17					
Wichita			20					
March 1972								
Colorado:[a]								
East							45 (2)	
Tennessee:[a]								
Fayetteville			11 (3)					

---

[a] State samples.
[b] Number in parentheses indicates number of samples.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Pub Health 49:225 (February 1969).

(2) U.S. ATOMIC ENERGY COMMISSION, DIVISION OF ISOTOPES DEVELOPMENT. Chart of the Nuclides, Tenth Edition revised to December 1968. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium-89 and strontium-90 measurements in milk, July 1971, Technical experiment 71-MKAQ-1. Analytical Quality Control Service, Office of Radiation Programs, EPA, Washington, D.C. 20460 (December 1971).

(*6*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(*7*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER and B. KAHN. The cause of relatively high cesium-137 concentrations in Tampa, Florida, milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Milk Surveillance Programs, July–September 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Milk Surveillance Network, operated by the NERC-LV,[1] consists of 30 sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the af-

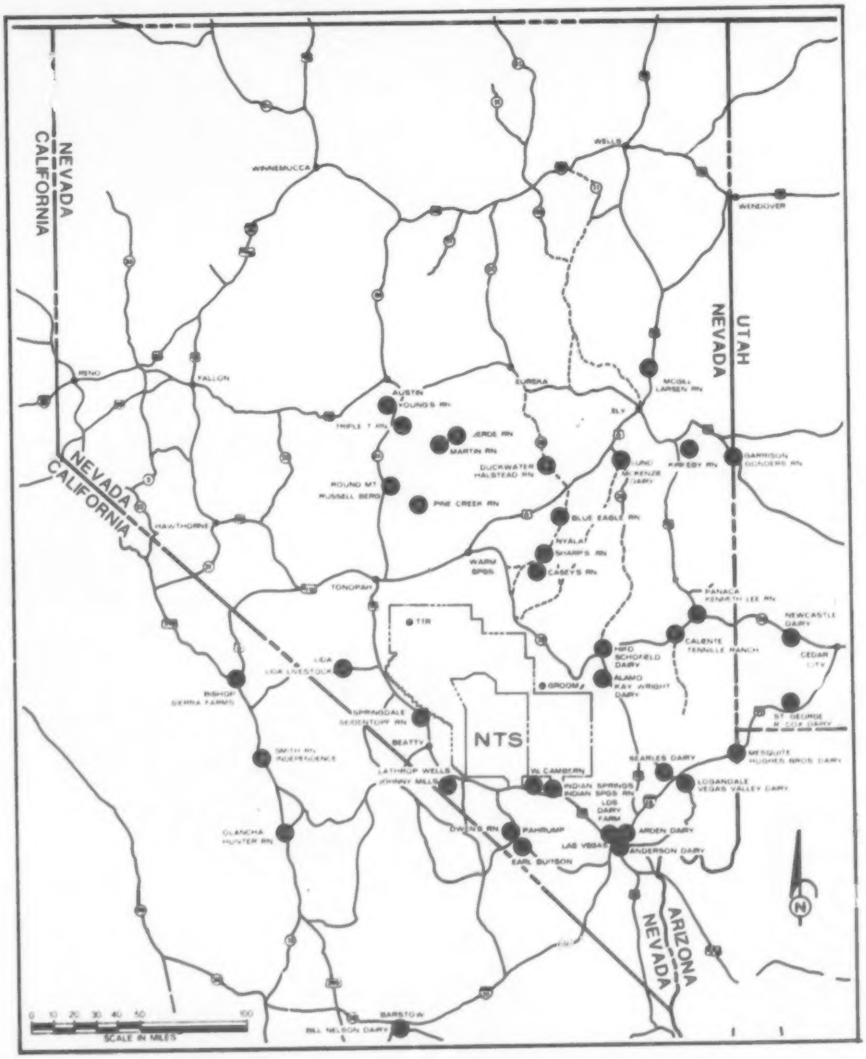
NEVADA
CALIFORNIA
WINNEMUCCA
WELLS
WENDOVER
UTAH
NEVADA
RENO
FALLON
AUSTIN
YOUNG'S RN
TRIPLE T RN
JERDE RN
MARTIN RN
EUREKA
MCGILL
LARSEN RN
ELY
DUCKWATER
HALSTEAD RN
LUND
MCKENZE DAIRY
KIRKEBY RN
GARRISON
BONDERS RN
ROUND MT
RUSSELL BERG
PINE CREEK RN
BLUE EAGLE RN
NYALA
SHARP'S RN
CASEY'S RN
WARM SPGS
HAWTHORNE
TONOPAH
NEVADA
CALIFORNIA
PANACA
KENNETH LEE RN
NEWCASTLE DAIRY
CALENTE
TENNILLE RANCH
CEDAR CITY
TIR
HIKO
SCHOFIELD DAIRY
ALAMO
KAY WRIGHT DAIRY
GROOM
LIDA
LIDA LIVESTOCK
BISHOP
SIERRA FARMS
SPRINGDALE
SEIDENTOPF RN
BEATTY
NTS
ST GEORGE
R COX DAIRY
SMITH RN
INDEPENDENCE
LATHROP WELLS
JOHNNY MILLS
W. CAMBERN
INDIAN SPRINGS
INDIAN SPGS RN
SEARLES DAIRY
MESQUITE
HUGHES BROS DAIRY
LOGANDALE
VEGAS VALLEY DAIRY
LOS DAIRY FARM
OLANCHA
HUNTER RN
OWEN'S RN
PAHRUMP
ARDEN DAIRY
LAS VEGAS
ANDERSON DAIRY
EARL BUTSON
ARIZONA
NEVADA
N
0 10 20 30 40 50 100
SCALE IN MILES
BARSTOW
BILL NELSON DAIRY

Figure 1. NERC-LV Milk Surveillance Network

---

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

Table 1. Milk surveillance results, July–September 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	7/6	11	<10	<2	4 ±2	NA
		8/2	11	<10	<5	<8	NA
		9/6	11	<10	<2	2.2±1.5	NA
Hinkley:							
Bill Nelson Dairy	13	7/3	12	<10	<1	<1	NA
		8/1	12	<10	<2	2 ±1	NA
		9/5	12	<10	<2	<1	NA
Independence:							
Smith Ranch	14	7/6	13	<10	<2	<1	NA
		8/2	13	<10	<2	3 ±1	NA
		9/5	13	<10	<2	1.8±1.4	NA
Olancha:							
Hunter Ranch	30	7/5	13	<10	2±2	<1	NA
Nevada:							
Alamo:							
Williams Dairy	1	7/5	12	<10	3±2	<2	NA
		8/1	12	<10	4±4	3 ±3	NA
		9/5	12	<10	<2	3.0±1.6	NA
Austin:							
Triple T Ranch	2	7/11	13	<10	6±4	7 ±2	670±210
Young's Ranch	3	9/6	13	<10	<3	1.7±1.6	NA
Belmont:							
Pine Creek Ranch	4	7/10	13	20	<2	2 ±1	NA
		8/1	13	20	<6	6 ±4	NA
		9/5	13	10	<4	3.9±2.1	NA
Caliente:							
Tennille Ranch	6	7/5	13	<10	5±2	1 ±1	NA
		8/3	13	<10	<4	2 ±2	NA
		9/5	13	<10	<2	<1.6	NA
Currant:							
Blue Eagle Ranch	7	7/12	13	50	3±2	4.0± .9	NA
Duckwater:							
Halstead Ranch	8	7/12	13	<10	6±2	3 ± .9	NA
		8/2	13	<10	<3	3 ±2	NA
		9/7	13	<10	<2	<1.5	NA
Eureka:							
Martin Ranch	10	7/22	13	[c] <100	7±3	5 ±1	NA
		8/24	13	<10	<3	6 ±1.9	NA
		9/19	13	<10	<3	4 ±2	NA
Hiko:							
Schofield Dairy	12	7/5	12	<10	3±2	<2	<200
		8/1	12	<10	<2	2 ±1	<210
		9/5	12	<10	2±2	<1.4	<230
Indian Springs:							
Cambern Ranch (A)	16						
Indian Springs Ranch	15						
Las Vegas:							
Anderson Dairy	17	7/11	11	<10	<2	2 ± .9	NA
		8/17	11	<10	2±2	<1.3	NA
		9/18	11	<10	<2	1.8±1.3	NA
Arden Dairy	18	7/11	11	<10	NA	NA	NA
		8/17	11	<10	<2	1.4±1.2	NA
		9/18	11	<10	2	1 ±1	NA
LDS Dairy Farms	19	7/11	12	<10	<2	<1	<220
		8/17	12	<10	<2	2 ±1.2	<270
		9/18	12	<10	<2	2.2±1.1	<200
Lathrop Wells:							
Mills Ranch	20	7/12	[illegible]	<10	<1	1 ± .7	NA
		8/2	13	<10	<3	<2	NA
Lida:							
Lida Livestock Company	21	7/9	13	<10	<2	4 ± .9	NA
		8/1	13	<10	<2	4 ±2	NA
Logandale:							
Vegas Valley Dairy	22	7/7	12	<10	<2	2 ±1	NA
		8/3	12	<10	4±4	<2	NA
		9/5	12	<10	<2	<1.3	NA
Lund:							
McKenzie Dairy	23	7/11	12	<10	3±2	3 ± .8	<230
		8/8	12	<10	3±3	2 ±2	320±200
		9/6	12	<10	<2	1.4±1.4	230±210
McGill:							
Larsen Ranch	24	7/10	13	<10	7±2	2 ± .9	NA
		9/7	13	<10	<2	1.2±1.2	NA
Mesquite:							
Hughes Bros Dairy	25	7/5	12	<10	<2	<1	220±220
		8/2	12	<10	<3	<2	<210
		9/5	12	<10	<2±2	<1.0	380±210
Moapa:							
Searles Dairy	26	7/5	12	<10	5±2	1 ± .8	NA
		8/1	12	<10	<4	5 ±2	NA
		9/5	12	<10	<2	1.7±1.4	NA

190

See footnotes at end of table.

Table 1. Milk surveillance results, July–September 1972—continued

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
Nevada—continued							
Nyala: Sharp's Ranch	28	7/5 8/2 9/7	13 13 13	[c] <100 10 <10	3 ±2 <2 NA	3 ±2 3 ±2 NA	220 ±220 <210 <210
Pahrump: Owens Ranch	31	7/14 8/3 9/5	13 13 13	<10 <10 <10	1 ±1 <3 <2	.9 ± .6 <2 <1.1	NA NA NA
Panaca: Kenneth Lee Ranch	33	7/5 8/2 9/6	13 13 13	<10 <10 <10	5 ±2 <5 <2	<2 4 ±3 2.9 ±1.5	NA NA NA
Round Mt: Russell Berg Ranch	34	7/11 8/2	13 13	20 <10	<2 <3	3 ± .9 4 ±2	NA NA
Shoshone: Kirkeby Ranch	35	7/12 9/6	13 13	<10 <10	3 ±2 <3	4 ±2 3.8 ±1.8	NA NA
Springdale: Seidentopf Ranch	36	7/11 8/2 9/1	13 13 13	<10 <10 <10	5 ±2 <2 <2	2 ± .9 3 ±1 1.6 ±1.3	NA NA NA
Utah:							
Garrison: Gonders Ranch	11	7/13 8/1 9/5	13 13 13	<10 <10 <10	<2 <2 <2	2 ± .8 3 ±2 <1.5	NA NA NA
New Castle: Newcastle Dairy	27	7/6 8/2 9/7	12 12 12	<10 <10 <10	2 ±2 <4 NA	2 ±1 <2 NA	NA NA NA
St. George: R. Cox Dairy	37	7/5 8/1	12 12	<10 <10	<2 3 ±3	3 ±2 <3	NA NA

[a] 11, pasteurized milk; 12, raw milk from Grade A producer(s); 13, raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
[c] Small sample size increased minimum detectable level.
A, Alternate milk sampling station.
NA, not analyzed.

fected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in July, August, and September 1972 by NERC-LV surveillance programs are listed in table 1. With the exception of cesium-137 at levels near the minimum detectable activity (MDA) (10 pCi/liter), no gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. Levels of tritium, strontium-89, and strontium-90 near the MDA's for these radionuclides (~ 200 pCi/liter, 2 pCi/liter, and 1 pCi/liter, respectively) were also measured by radiochemistry analyses. Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January–June 1971	December 1972
Carbon-14 in Total Diet and Milk	July–December 1971	May 1972
Connecticut Standard Diet	January–December 1971 This network has been discontinued	December 1972
Institutional Total Diet	October–December 1971 and 1971 Annual Summary	June 1972
Radiostrontium in Milk	January–December 1971	November 1972
Strontium-90 in Tri-City Diets	January–December 1971	December 1972

192

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January–December 1971	February 1973
Michigan	January–June 1970	November 1971
Minnesota Municipal Water	July 1970–June 1971	November 1972
New York	July–December 1970 and January–June 1971	May 1972
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water	July–December 1971	November 1972
Tritium Surveillance System	July–September 1972	February 1973
Washington	July 1969–June 1970	March 1972
Water Surveillance Programs	April–June 1972	February 1973

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States June–September 1972

Office of Water Planning and Standards
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Planning and Standards. Regional offices of the Environmental Protection Agency are responsible for the collection and retrieval system. Radioactivity analysis was performed in the centralized laboratories of the Office of Water Planning and Standards (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). With the publication of data for January 1971, this activity was resumed as a monthly report series. The unpublished data for the time interval of November 1968 through December 1970 will be the subject of a future summary article.

Tables 1 through 4 present the gross alpha and beta radioactivity results for samples collected from rivers during June through September 1972. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are collected for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th Edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 1. Gross radioactivity in U.S. surface waters, June 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Allegheny River:					
Pittsburgh, Pa	2	<0.2	<0.4	<1	5
		.4	<.3	<1	2
Animas River:					
Durango, Colo	1	<1.9	.9	32	2
Bear River:					
Idaho-Utah State Line	1	<.4	<1.0	4	10
Beaver River:					
New Brighton, Pa	1	<.3	<.6	<1	9
Big Sandy River:					
Wayne Co., W. Va	1	1.3	<.8	5	1
Clinch River:					
Kingston, Tenn	3	7.4	<1.0	18	7
		2.2	1.2	2	2
		<.3	<.4	<1	5
Colorado River:					
DeBeque, Colo	1	.8	<.7	6	10
Lake Granby, Colo	1	<.3	.3	<1	3
Lee's Ferry, Ariz	1	<.3	5.7	2	15
Moab, Utah:					
Highway bridge	4	<2.9	<1.1	37	12
		6.3	2.3	24	9
		7.6	3.7	28	18
		1.5	3.9	10	18
Above Mill Creek, Utah	4	5.0	2.2	27	12
		.2	2.4	28	13
		8.6	2.2	32	11
		3.7	5.8	9	18
Silt, Colo	1	.5	1.0	4	7
Detroit River:					
Detroit, Mich	1	<.3	<.5	2	3
Trenton, Mich	1	.3	.4	3	4
Dolores River:					
Bedrock, Colo	4	<.7	<.7	9	4
		<2.2	<.6	29	5
		1.1	1.7	7	10
		.4	6.5	4	25
Gateway, Colo	5	3.8	2.3	17	10
		<2.9	<1.0	25	10
		2.2	4.8	11	30
		.6	3.0	4	34
		1.0	4.6	5	25
Guyandotte River:					
Guyandotte, W. Va	1	1.0	<.4	5	3
Kanawha River:					
Mason, W. Va	1	<.3	.5	<1	5
Winfield Dam, W. Va	1	<.2	<.3	2	3
Mississippi River:					
Burlington, Iowa	1	<.3	<.3	2	4
Missouri River:					
Huron, S. Dak	1	3.1	<1.2	15	26
Omaha, Nebr	1	2.4	6.4	21	19
Yankton, S. Dak	1	<.3	2.3	3	15
Monongahela River:					
Pittsburgh, Pa	2	1.3	<.5	<2	5
		<.2	<.5	<1	3
Muskingum River:					
Lock & Dam #2, Ohio	1	<.2	<1.4	<1	16
North Platte River:					
Henry, Nebr	1	.3	18.6	4	43
Ohio River:					
Addison, Ohio	1	3.0	2.1	9	2
Boyd Co., Ky	1	1.1	<.5	4	5
Cincinnati, Ohio	4	.6	1.5	10	8
		1.0	<.8	3	5
		<.3	<.7	3	8
		3.1	<.4	12	6
Gallipolis, Ohio	1	.5	<.4	<1	8
Hancock, W. Va	1	<.2	<.4	<1	3
Kyger Creek, W. Va	1	.6	<.6	<2	4
Marietta, Ohio	1	.5	<.4	<1	3
New Martinsville, W. Va	1	.3	<.5	<1	3
Old Lock, W. Va	1	<.2	<.4	<1	2
South Heights, Pa	1	.3	<.4	<1	4
Warwood, W. Va	1	<.2	<.6	<1	5
Platte River:					
Plattsmouth, Nebr	1	6.8	4.0	28	22
Roanoke River:					
John Kerr Dam, Va	4	<.3	<.3	2	3
		<.4	.9	3	2
		<.3	<.4	3	5
		.4	<.3	2	4
San Miguel River:					
Uravan, Colo	4	<1.5	2.0	14	5
		<2.7	<.8	32	7
		2.7	.5	12	6
		<.3	1.4	2	6

195

Table 1. Gross radioactivity in U.S. surface waters, June 1972—continued

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Below Uravan, Colo	5	<1.9 6.2 6.5 .6 2.1	<1.1 <1.0 1.4 2.5 4.0	22 93 32 7 8	8 8 13 11 14
Naturita, Colo	5	4.4 13.2 .6 .4 <.3	1.0 1.1 1.0 <.5 .8	17 27 4 4 2	3 4 6 7 5
St. Clair River:					
Port Huron, Mich	1	<.3	<.4	3	3
St. Lawrence River:					
Massena, N.Y	3	<.4 .5 <.3	<.6 .7 <.5	5 3 3	8 7 6
St. Mary's River:					
Sault Ste. Marie, Mich	1	<.3	<.4	3	2
White River:					
Watson, Utah	1	<2.7	<1.2	24	11

Table 2. Gross radioactivity in U.S. surface waters, July 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Clinch River:					
Kingston, Tenn	1	<0.3	2.4	<1	<2
Colorado River:					
Moab, Utah:					
Highway bridge	3	1.5 <.3 <.3	5.6 10.3 12.8	11 2 2	17 14 21
Above Mill Creek, Utah	3	1.9 .3 .6	2.4 7.1 15.2	7 <2 1	17 4 30
Lee's Ferry, Ariz	1	<.3	6.9	<1	16
Dolores River:					
Bedrock, Colo	4	.4 .4 <.3 2.7	9.0 4.8 7.7 5.2	19 2 1 9	22 29 85 86
Gateway, Colo	4	1.8 14.9 5.5 21.4	6.8 8.6 17.5 6.2	9 36 15 46	15 29 44 57
Lake Utah:					
Spanish Fork, Utah	1	.3	<2.4	2	8
Little Medicine Bow River:					
Heward Ranch, Wyo	1	.3	13.7	<1	31
Near Shirley Basin, Wyo	1	3.8	26.3	28	30
Above Seminole Reservoir, Wyo	1	.6	29.1	3	67
Mississippi River:					
Burlington, Iowa	1	.7	2.5	6	8
Ohio River:					
Cincinnati, Ohio	4	1.9 .9 .4 <.3	<.4 <.5 <.5 <.6	9 6 1 <1	4 5 4 3
Powder River:					
Near Arvada, Wyo	1	6.6	12.6	15	37
Provo River:					
Provo, Utah	1	<.3	1.5	<1	6
Roanoke River:					
John Kerr Dam, Va	3	.9 .6 .5	<.3 <.3 <.3	5 3 2	4 4 4
San Juan River:					
Bluff, Ariz	1	.8	3.8	16	22
San Miguel River:					
Uravan, Colo	4	4.4 .8 .3 3.7	4.2 3.1 3.9 6.2	12 5 2 19	10 10 11 17
Below Uravan, Colo	4	3.9 .5 .3 7.4	5.1 6.4 14.8 8.7	14 4 3 16	10 14 25 33

Table 2. Gross radioactivity in U.S. surface waters, July 1972—continued

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Naturita, Colo	4	.9	<.9	5	6
		<.3	2.5	<1	5
		<.3	3.5	1	4
		<.3	<1.2	1	6
St. Lawrence River:					
Massena, N.Y	3	<.3	<.6	2	5
		<.4	<.5	3	5
		<.3	<.7	1	2
White River:					
Watson, Utah	1	<.8	2.3	2	9

Table 3. Gross radioactivity in U.S. surface waters, August 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Bear River:					
Utah-Idaho State Line, Utah	1	<0.3	1.6	1	13
Clinch River:					
Kingston, Tenn	4	<.3	.5	<1	6
		<.3	<.4	<1	7
		<.2	<.3	1	4
		<.2	<.3	<1	2
Colorado River:					
DeBeque, Colo	1	<.3	<.2	<2	<6
Moab, Utah Highway bridge	5	2.5	13.4	8	34
		4.0	8.3	11	23
		<.3	18.4	2	23
		4.0	19.4	13	22
		4.4	22.4	12	36
Above Mill Creek, Utah	5	<.7	6.7	11	23
		3.8	13.3	15	28
		2.2	16.9	11	34
		2.3	19.9	11	43
		3.9	15.8	19	42
Silt, Colo	1	<.3	2.7	1	7
Dolores River:					
Bedrock, Colo	4	.5	12.1	4	27
		.9	12.1	4	30
		<.9	22.5	13	39
		1.1	10.6	9	23
Gateway, Colo	5	1.8	12.4	6	35
		1.6	20.4	6	56
		4.2	21.5	12	83
		1.6	13.3	10	74
		2.0	15.2	9	83
Green River:					
Greendale, Utah	1	<.3	2.1	<1	12
LaBarge, Wyo	1	<.3	<.4	<1	3
Little Medicine Bow River:					
Heward Ranch, Wyo	1	1.1	12.1	<1	22
Above Seminole Reservoir, Wyo	1	2.9	78.0	13	21
Near Shirley Basin, Wyo	1	3.4	92.2	28	528
Ohio River:					
Cincinnati, Ohio	5	.4	<.6	<1	4
		.4	<.4	2	3
		<.2	<.2	<1	10
		<.2	<.4	<1	7
		<.3	<.2	<1	<1
Roanoke River:					
John Kerr Dam, Va	3	<.3	<.3	<1	4
		<.2	<.3	<1	8
		<.2	<.5	<1	5
San Miguel River:					
Uravan, Colo	5	<.3	7.1	1	12
		<.3	5.9	<1	19
		<.2	6.2	<1	17
		<.3	7.6	<1	14
		.8	5.7	5	20
Below Uravan, Colo	5	1.4	4.5	8	20
		1.7	6.9	4	31
		1.5	41.9	4	56
		2.9	23.9	18	49
		.8	29.6	5	46
Naturita, Colo	5	<.3	3.5	1	16
		<.3	5.5	<1	17
		<.2	<3.4	<1	15
		<.3	4.1	<1	17
		<.3	3.8	<1	15
St. Lawrence River:					
Massena, N.Y	3	<.3	<.5	1	11
		<.3	<.5	1	5
		<.2	<.4	2	4

197

Table 4. Gross radioactivity in U.S. surface waters, September 1972

River and station	Number of grab samples	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Animas River:					
Durango, Colo	1	<0.4	<0.7	<1	4
Colorado River:					
Colorado-Utah State Line	1	4.1	15.9	27	26
Moab, Utah Highway bridge	4	7.5	18.3	18	27
		5.3	9.3	15	34
		23.6	1.5	35	11
		5.0	7.7	20	21
Above Mill Creek, Utah	4	4.4	20.4	17	25
		6.9	16.6	25	31
		14.1	1.1	38	12
		5.7	8.8	29	25
Lake Granby, Colo	1	<.3	<.3	<1	2
Dolores River:					
Bedrock, Colo	4	14.9	4.0	20	18
		1.6	12.4	7	42
		2.3	21.6	8	60
		2.5	15.6	10	33
Gateway, Colo	4	12.9	28.1	23	67
		15.6	31.9	48	79
		36.4	10.7	81	36
		18.0	18.6	43	55
Little Medicine Bow River:					
Heward Ranch, Wyo	1	.4	7.3	5	14
Seminole Reservoir, Wyo	1	5.2	17.6	18	34
Shirley Basin, Wyo	1	7.7	27.4	6	31
Ohio River:					
Cincinnati, Ohio	4	<.3	<.6	2	4
		.4	<.5	<1	5
		<.3	<.3	<1	6
		<.3	<.9	<1	6
Roanoke River:					
John Kerr Dam, Va	2	<.3	<.8	<1	5
		<.3	<.3	1	3
San Miguel River:					
Uravan, Colo	4	12.9	5.4	1	20
		6.9	7.1	22	15
		2.4	<3.1	8	14
		.7	4.5	3	10
Below Uravan, Colo	4	2.7	25.4	10	41
		3.5	11.3	16	26
		.6	12.1	3	22
		.9	9.4	7	18
Naturita, Colo	3	.6	3.3	<1	8
		<.4	2.7	1	7
		<.3	<4.2	1	20
St. Lawrence River:					
Massena, N. Y	3	.3	<.6	<1	> 6
		<.3	<.6	<1	6
		<.3	<.5	<1	3
Virgin River:					
St. George, Utah	1	25.7	17.8	121	58

Water Surveillance Programs, July–September 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network, operated by the National Environmental Research Center-Las Vegas (NERC-LV),[1] consist of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

---

[1] This network is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, AEC, Las Vegas, Nev.

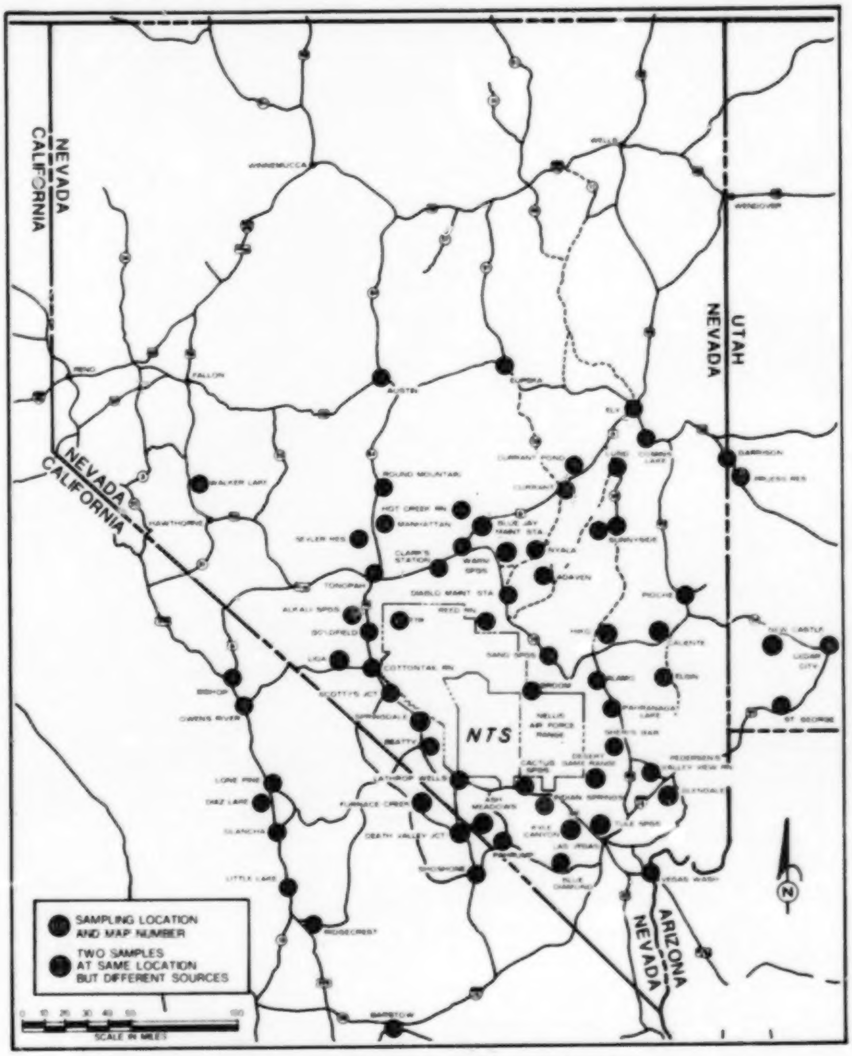
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
WELLS
WENDOVER
RENO
FALLON
AUSTIN
EUREKA
ELY
GARRISON
CURRANT POND
CURRANT
ROUND MOUNTAIN
WALKER LAKE
HOT CREEK RN
MANHATTAN
BLUE JAY MAINT STA
HAWTHORNE
SEXLER RES
SUNNYSIDE
CLARK'S STATION
WARM SPGS
NYALA
ADAVEN
TONOPAH
DIABLO MAINT STA
PIOCHE
ALKALI SPGS
REED RN
GOLDFIELD
HIKO
CALIENTE
NEW CASTLE
CEDAR CITY
LIDA
COTTONTAIL RN
SAND SPGS
BISHOP
SCOTTY'S JCT
ALAMO
ELGIN
OWENS RIVER
SPRINGDALE
NELLIS AIR FORCE RANGE
PAHRANAGAT LAKE
ST GEORGE
NTS
BEATTY
LONE PINE
LATHROP WELLS
CACTUS SPGS
DESERT GAME RANGE
PEDERSEN'S VALLEY VIEW RN
GLENDALE
DIAZ LAKE
FURNACE CREEK
ASH MEADOWS
INDIAN SPRINGS
OLANCHA
DEATH VALLEY JCT
KYLE CANYON
TULE SPGS
LAS VEGAS
PAHRUMP
SHOSHONE
BLUE DIAMOND
VEGAS WASH
LITTLE LAKE
RIDGECREST
ARIZONA
NEVADA
N
SAMPLING LOCATION AND MAP NUMBER
TWO SAMPLES AT SAME LOCATION BUT DIFFERENT SOURCES
0 10 20 30 40 50 100
SCALE IN MILES
BARSTOW

Figure 1. Water Surveillance Network

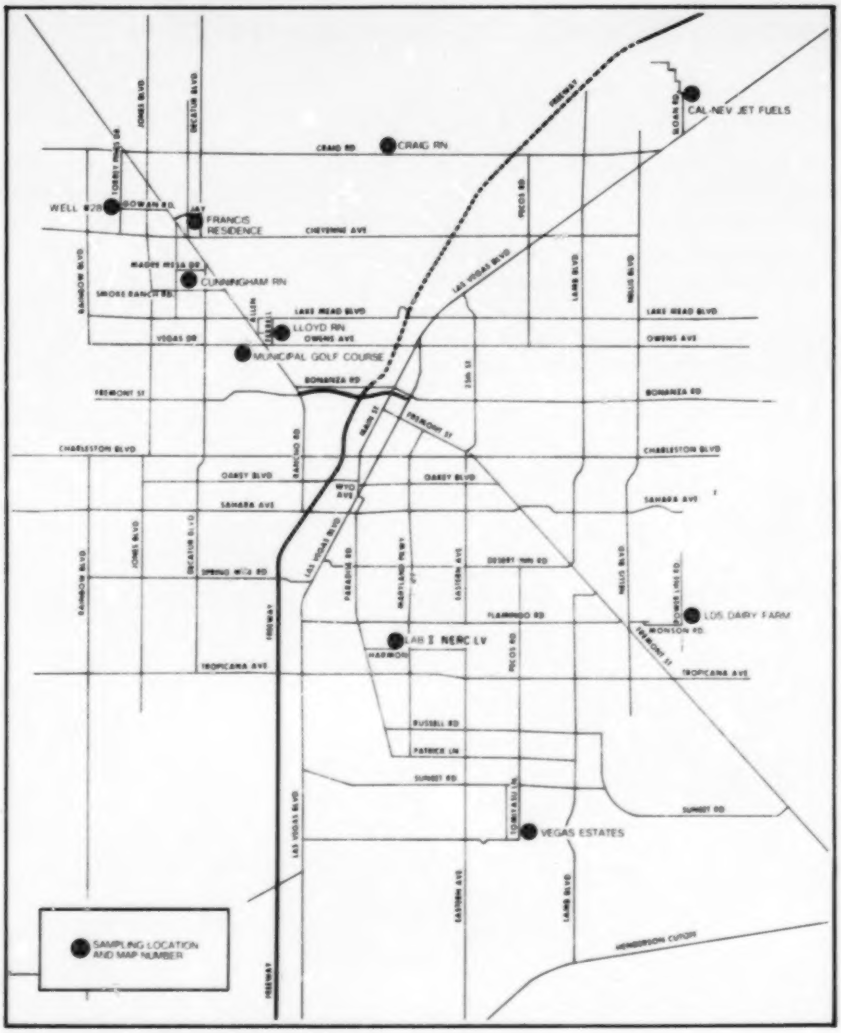
CRAIG RD
CRAIG RN
CAL-NEV JET FUELS
SLOAN RD
FREEWAY
WELL #28
GOWAN RD.
JAY
FRANCIS RESIDENCE
CHEYENNE AVE
MADRE MESA DR
CUNNINGHAM RN
SMOKE RANCH RD.
LAKE MEAD BLVD
LLOYD RN
OWENS AVE
VEGAS DR
MUNICIPAL GOLF COURSE
BONANZA RD
FREMONT ST
MAIN ST
CHARLESTON BLVD
OAKEY BLVD
WYO AVE
SAHARA AVE
SPRING MTN RD
DESERT INN RD
FLAMINGO RD
LOS DAIRY FARM
MONSON RD.
LAB I NERC LV
HARMON
TROPICANA AVE
RUSSELL RD
PATRICK LN
SUNSET RD
VEGAS ESTATES
TOMIYASU LN
HENDERSON CUTOFF
RAINBOW BLVD
JONES BLVD
DECATUR BLVD
TORREY PINES DR
ALLEN
RANCHO RD
LAS VEGAS BLVD
PARADISE RD
MARYLAND PKWY
EASTERN AVE
25th ST
PECOS RD
LAMB BLVD
NELLIS BLVD
POWER LINE RD
SAMPLING LOCATION AND MAP NUMBER

Figure 2. Water Surveillance Network, Las Vegas Valley

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports*.

Results

The analytical results of all water samples collected in July, August, and September 1972 by the NERC-LV Water Surveillance Network are listed in table 1. No gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. The analytical results of samples selected for special analyses will be reported at a later date.

For the purpose of identifying the source of the gross radioactivity in all network samples

Table 1. NERC-LV water surveillance results, July–September 1972

Location	Map number	Data collected 1972	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish and Game Office	9	7/6	23	<1.8	<3.4	NA
		8/2	23	<1.6	10 ± 4	NA
		9/6	23	<2.2	<3.1	NA
Owens River, 3 miles east	10	7/6	22	<3.1	<3.5	NA
		8/2	22	<3.3	5 ± 3	NA
		9/6	22	9 ± 5	7 ± 3	NA
Death Valley Junction:						
Lila's Cafe	21	7/5	23	14 ± 7.8	10 ± 4	<200
		8/3	23	6 ± 6	9 ± 4	<200
		9/8	23	12 ± 8.7	9 ± 4	<210
Furnace Creek:						
Pond	28	7/5	21	8 ± 6	8 ± 4	NA
		8/3	21	<5.5	9 ± 4	NA
		9/8	21	<6.3	12 ± 3.9	NA
Visitors Center	29	7/5	27	7 ± 5	9 ± 4	NA
		8/3	27	<4.4	16 ± 4.2	NA
		9/8	27	<6.2	11 ± 3.8	NA
Hinkley:						
Bill Nelson Dairy	39	7/3	23	9 ± 4	9 ± 4	NA
		8/1	23	12 ± 6.8	9 ± 4	NA
		9/5	23	<6.9	10 ± 4	NA
Little Lake:						
Little Lake Ranch	60	7/7	21	<7.1	21 ± 4.8	NA
		8/1	21	27 ±10	32 ± 5	NA
		9/5	21	19 ± 9.2	19 ± 4.2	NA
Lone Pine:						
Diaz Lake	61	7/5	21	25 ± 9.2	21 ± 4.6	NA
		8/2	21	27 ± 9.5	26 ± 4.7	NA
		9/5	21	24 ± 9.4	29 ± 4.7	NA
Forest Service Ranger Station	62	7/5	23	<2.1	<3.5	NA
		8/2	23	<1.8	4 ± 3	NA
		9/5	23	<2.6	<3.1	NA
Olancha:						
Haiwee Reservoir	73	7/7	21	5 ± 3	6 ± 4	NA
		8/1	21	5 ± 4	5 ± 3	NA
		9/5	21	8 ± 4	11 ± 3.6	NA
Ridgecrest:						
City Hall	76	7/7	23	<4.2	<3.5	NA
		8/1	23	7 ± 5	5 ± 3	NA
		9/5	23	4 ± 4	<3.1	NA
Shoshone:						
Chevron Service Station	79	7/5	27	7 ± 6	19 ± 4.4	NA
		8/3	27	<5.3	18 ± 4.4	NA
		9/8	27	<7.4	15 ± 4.1	NA
Nevada:						
Adaven:						
Canfield Ranch	1	7/6	22	5 ± 3	4 ± 3	NA
		8/2	22	<3.3	4 ± 3	NA
		9/7	22	4 ± 4	4 ± 3	NA
Alamo:						
Sheri's Bar	2	7/5	23	<3.0	5 ± 3	NA
		8/1	23	<3.9	4 ± 3	NA
		9/5	23	<4.8	7 ± 3	NA
Pahranagat Lake	3	7/5	21	12 ± 7.0	30 ± 4.7	NA
		8/1	21	22 ± 9.2	35 ± 5.0	NA
		9/5	21	30 ±11	37 ± 5.1	NA
Williams Dairy	4	7/5	23	<4.9	15 ± 3.9	NA
		8/1	23	8 ± 5	12 ± 3.9	NA
		9/5	23	<5.9	13 ± 3.9	NA
Ash Meadows:						
Ash Meadows Lodge	5	7/11	23	<6.3	16 ± 4.1	380 ±230
		8/2	23	10 ± 6.8	15 ± 4.2	220 ±200
		9/2	23	6 ± 6	16 ± 4.0	<230
Ash Meadows Pond	6	7/11	21	<6.3	23 ± 4.5	NA
		8/2	21	7 ± 5	22 ± 4.5	NA
		9/2	21	14 ± 7.1	23 ± 4.3	NA
Austin:						
County Courthouse	7	7/13	27	24 ± 6.5	24 ± 4.3	NA
		8/1	27	<3.3	<3.1	NA
		9/7	27	30 ± 7.5	15 ± 3.8	NA
Beatty:						
Richfield Service Station	8	7/10	23	9 ± 6	10 ± 4	240 ±220
		8/2	23	10 ± 6	9 ± 4	<200
		9/1	23	5 ± 5	7 ± 3	<230
Blue Diamond:						
Post Office	11	7/11	23	<3.6	13 ± 2.4	<220
		8/3	23	9 ± 5	<3.3	<200
		9/6	23	<4.0	4 ± 3	<230
Blue Jay Highway Maintenance Station	12	7/6	23	<3.8	9 ± 3	NA
		8/1	23	<3.7	5 ± 3	NA
		9/7	23	<4.2	5 ± 3	NA

See footnotes at end of table.

Table 1. NERC-LV water surveillance results, July-September 1972—continued

Location	Map number	Data collected 1972	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada—continued						
Cactus Springs:						
Mobile Service Service	13	7/13	27	<2.7	<3.1	360 ±220
		8/1	27	3 ± 2	<3.3	200 ±200
		9/5	27	4 ± 3	<2.9	<230
Caliente:						
Agricultural Extension Station	14	7/6	23	5 ± 4	4 ± 3	NA
		8/2	23	<3.1	7 ± 3	NA
		9/6	23	11 ± 5.7	5 ± 3	NA
Meadow Valley Wash	15	7/6	22	6 ± 5	13 ± 3.8	NA
		8/2	22	10 ± 5.6	13 ± 3.9	NA
		9/7	22	12 ± 7.3	12 ± 3.8	NA
Clark Station:						
Five-Mile Ranch	17	7/6	27	<3.5	<3.3	NA
		8/1	27	<3.0	5 ± 3	NA
		9/7	27	5 ± 4	6 ± 3	NA
Coyote Summit:						
Sand Spring Well	18	7/6	23	<3.4	8 ± 3	NA
		8/2	23	6 ± 4	13 ± 3.7	NA
Currant:						
Currant Pond	19	7/12	21	10 ± 5	8 ± 4	NA
		8/2	21	<3.8	7 ± 4	NA
		9/7	21	10 ± 5.8	4 ± 3	NA
Currant Ranch Cafe	20	7/12	27	14 ± 5.9	<3.3	NA
		8/2	27	6 ± 5	4 ± 3	NA
		9/7	27	7 ± 6	6 ± 3	NA
Diablo Highway Maintenance Station	22	7/6	23	<3.5	5 ± 3	NA
		8/2	23	4 ± 4	9 ± 3	NA
		9/6	23	<4.1	6 ± 3	NA
Diablo:						
Reed Ranch	23	7/5	21	<5.3	9 ± 4	NA
		8/1	21	22 ± 8.2	43 ± 5.2	NA
		9/6	21	35 ± 9.3	9 ± 4	NA
Elgin:						
Water tower	24	7/6	23	15 ± 7.0	11 ± 3.8	NA
		8/3	23	5 ± 5	9 ± 4	NA
		9/7	23	7 ± 6	10 ± 3.6	NA
Ely:						
Chevron Service Station	25	7/10	24	6 ± 4	4 ± 3	NA
		8/1	24	5 ± 3	<3.1	NA
		9/6	24	<3.3	<3.2	NA
Comins Lake	26	7/14	21	<7.1	13 ± 3.9	NA
		8/1	21	13 ± 7.5	49 ± 5.6	NA
		9/6	21	12 ± 8.0	59 ± 6	NA
Eureka:						
Chevron Service Station	27	7/13	24	<3.1	<3.3	NA
		8/1	24	7 ± 4	4 ± 3	NA
		9/7	24	<4.9	<3.2	NA
Glendale:						
Chevron Service Station	32	7/5	27	10 ± 6	16 ± 4.0	NA
		8/1	27	<5.1	9 ± 4	NA
		9/5	27	<5.9	9 ± 4	NA
Muddy River	33	7/5	22	<8.0	13 ± 4.0	NA
		8/1	22	10 ± 6	9 ± 4	NA
		9/5	22	<6.8	17 ± 4.2	NA
Goldfield:						
Alkali Springs	34	7/10	21	<7.7	28 ± 4.9	NA
		8/1	21	<6.7	30 ± 5.2	NA
		9/5	21	<8.2	22 ± 4.5	NA
Chevron Service Station	35	7/10	23	6 ± 5	5 ± 3	NA
		8/1	23	<4.7	4 ± 3	NA
		9/5	23	<5.1	4 ± 3	NA
Hawthorne:						
Walker Lake	36	9/8	21	<24	390 ±27	NA
Hiko:						
Crystal Springs	37	7/5	27	<4.5	6 ± 3	NA
		8/1	27	9 ± 5	7 ± 3	NA
		9/5	27	8 ± 5	6 ± 3	NA
Schofield Dairy	38	7/5	23	51 ± 9.5	35 ± 4.9	NA
		8/1	23	30 ± 9.2	39 ± 5.2	NA
		9/5	23	26 ± 9.3	36 ± 5.0	NA
Indian Springs:						
Chevron Service Station	40	7/13	23	<2.8	<3.1	<220
		8/1	23	14 ± 5.1	4 ± 3	<200
		9/5	23	4 ± 3	<3.3	<230
Las Vegas:						
Cal-Nev Jet Fuels	41	7/10	23	4 ± 3	10 ± 4	<200
		8/17	23	5 ± 4	3 ± 3	<270
		9/15	23	<3.8	4 ± 3	<230
Craig Ranch Golf Course	42	7/10	23	6 ± 3	5 ± 3	<200
		8/17	23	6 ± 4	6 ± 3	<270
		9/15	23	<4.1	5 ± 3	<230
Cunningham Ranch	43	7/10	23	<2.8	4 ± 3	<200
		8/17	23	<3.1	4 ± 3	<270
		9/15	23	<4.5	6 ± 3	<230

See footnotes at end of table.

202

Table 1. NERC-LV water surveillance results, July–September 1972—continued

Location	Map number	Data collected 1972	Radioactivity concentration ᵃ (pCi/liter)			
			Sample type ᵇ	Gross alpha	Gross beta	Tritium
Nevada—continued						
Desert Game Range	44	[illegible]/13	23	5± 3	11± 3.6	<220
		8/1	23	5± 3	<3.3	<220
		9/5	23	6± 4	4± 3	<230
Desert Game Range Pond	45	7/13	21	<2.7	<2.9	<220
		8/1	21	5± 3	<3.3	260 ±200
		9/5	21	5± 4	<3.1	<230
Francis Residence	46	7/10	23	<5.1	<3.2	200 ±200
		8/17	23	5± 5	<3.4	<270
		9/15	23	<6.3	5± 3	<230
Lab II, NERC-LV	47	7/10	24	<4.6	8± 4	1,000 ±210
		8/17	24	<5.6	8± 3	940 ±280
		9/15	24	<6.6	7± 4	400 ±230
Lake Mead Vegas Wash	48	7/11	21	6± 5	8± 3	950 ±230
		8/17	21	<5.7	8± 3	820 ±280
		9/15	21	<6.7	9± 4	950 ±240
LDS Dairy Farm	49	7/11	23	12± 3.6	13± 4.2	<220
		8/17	23	<9.2	13± 4.2	<270
		9/18	23	<9.4	16± 4.4	<200
Lloyd Ranch	50	7/10	23	7± 5	7± 3	200 ±200
		8/17	23	<5.6	6± 3	<270
		9/15	23	7± 7	6± 3	<230
LV Water District Well 28	51	7/10	23	4± 3	3± 3	<200
		8/17	23	<2.5	<3.3	<270
		9/15	23	<4.2	4± 3	<230
Municipal Golf Course	52	7/10	23	3± 3	7± 3	240 ±200
		8/17	23	4± 3	4± 3	<270
		9/15	23	<4.5	<3.2	<250
Tule Springs	53	7/13	23	<2.6	4± 3	<230
		8/1	23	4± 3	<3.3	<200
		9/5	23	<4.2	<3.3	<230
Tule Springs Pond	54	7/13	21	<2.9	4± 3	NA
		8/1	21	4± 3	<3.3	NA
		9/5	21	<2.1	4± 3	NA
Vegas Estates	55	7/10	23	<4.1	9± 4	<200
		8/17	23	<6.3	13± 3.8	<270
		9/15	23	<6.9	11± 3.5	<230
Lathrop Wells:						
Texaco Service Station	56	7/12	23	<4.2	6± 3	<230
		8/1	23	<3.5	<3.4	<200
		9/1	23	<6.1	<3.3	<230
Lida Junction:						
Cottontail Ranch	57	7/10	23	5± 5	14± 3.9	NA
		8/1	23	6± 5	15± 3.9	NA
		9/5	23	<6.7	11± 3.8	NA
Lida:						
Lida Livestock Company	58	7/10	27	5± 4	<3.1	NA
		8/1	27	4± 4	4± 3	NA
		9/5	27	<4.2	3± 3	NA
Pond at storage tank	59	7/10	21	<3.8	4± 3	NA
		8/1	21	<4.0	4± 3	NA
		9/5	21	<4.0	4± 3	NA
Lund:						
Gardner Grocery	63	7/11	23	6± 4	9± 4	NA
		8/3	23	5± 4	4± 3	NA
		9/6	23	<4.7	<3.2	NA
Manhattan:						
Country store	64	7/11	23	17± 7.1	10± 4	NA
		8/2	23	15± 6.9	7± 3	NA
		9/6	23	24± 8.4	10± 4	NA
Seyler Reservoir	65	9/6	21	33± 16	65± 6.9	NA
Mercury:						
Gordon Lake	66	7/5	23	<3	<1	NA
		8/1	23	5± 4	6± 3	NA
		9/6	23	<4.2	6± 3	NA
Moapa:						
Pedersen Valley View Ranch	67	7/5	27	8± 5	12± 3.7	NA
		8/1	27	<5.3	14± 3.9	NA
		9/5	27	<6.0	12± 3.9	NA
Mt. Charleston:						
Kyle Canyon Fire Station	68	7/13	27	<2.6	<2.9	420 ±220
		8/1	27	4± 3	<3.3	270 ±200
		9/5	27	<2.5	<2.9	290 ±230
Kyle Canyon Pond	69	7/13	21	<2.6	8± 3	280 ±230
		8/1	21	3± 3	11± 3.8	NA
		9/5	21	<2.5	10± 3.4	NA
Nyala:						
Sharp's Ranch	72	7/6	23	<3.1	3± 3	NA
		8/2	23	<3.2	5± 3	NA
		9/7	23	<3.5	5± 3	NA
Pahrump:						
Texaco Service Station	74	7/11	23	6± 4	4± 3	NA
		8/3	23	<3.3	3± 3	NA
		9/5	23	<2.4	<2.9	NA

See footnotes at end of table.

Table 1. NERC-LV water surveillance results, July–September 1972—continued

Location	Map number	Data collected 1972	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada—continued						
Pioche:						
County Courthouse	75	7/6	24	<3.9	7± 3	NA
		8/2	24	<2.7	7± 3	NA
		9/6	24	<3.5	5± 3	NA
Round Mt:						
Mobile Service Station	77	7/12	27	<2.6	<3.1	NA
		8/1	27	3± 2	<3.3	NA
		9/6	27	<2.9	<3.1	NA
Scotty's Junction:						
Chevron Service Station	78	7/10	23	<5.8	12± 3.8	<200
		8/1	23	7± 5	10± 4	<200
		9/5	23	<6.3	13± 3.9	<210
Springdale:						
Peacock Ranch	80	7/11	27	<4.7	9± 4	<230
		8/2	27	6± 5	7± 4	<200
		9/1	27	<3.8	8± 3	<230
Pond	81	7/11	21	<5.1	12± 3.7	NA
		8/2	21	<4.4	11± 3.8	NA
		9/1	21	8± 5	9± 3	NA
Sunnyside:						
Adam McGill Reservoir	83	7/11	21	6± 4	16± 4.0	NA
		8/3	21	10± 5.0	7± 3	NA
		9/6	21	11± 5.6	11± 3.7	NA
Wildlife Management Headquarters	84	7/11	27	5± 3	10± 3.7	NA
		8/3	27	<3.1	4± 3	NA
		9/6	27	<4.6	<3.2	NA
Tonopah:						
Jerry's Chevron Station	85	7/11	23	4± 4	10± 4	NA
		8/2	23	6± 4	12± 3.9	NA
		9/6	23	<3.7	NA	NA
Tonopah Test Range CP-1	86	7/11	23	6± 5	7± 3	NA
		8/2	23	<4.5	7± 3	NA
		9/5	23	<4.6	6± 3	NA
Warm Springs:						
Fallini's Pond	87	7/6	21	30±13	98± 7.9	NA
		8/2	21	NA	NA	NA
		9/6	21	13±10	70± 6.7	NA
Hot Creek Ranch	88	7/6	27	7± 5	20± 4.3	NA
		8/1	27	<5.8	12± 3.8	NA
		9/7	27	<5.8	18± 4.1	NA
Service Station and Cafe	89	7/5	27	30± 9.7	27± 4.6	NA
		8/2	27	28±10	25± 4.5	NA
		9/7	27	13± 7.9	28± 4.7	NA
Twin Springs Ranch	90	7/6	23	13± 6.3	13± 3.8	NA
		8/2	23	<3.0	<3.4	NA
		9/7	23	19± 7.3	13± 3.8	NA
Utah:						
Cedar City:						
M. D. Baldwin Reservoir	16	7/6	24	<2.6	10± 2	NA
		8/1	24	4± 3	3± 3	NA
		9/6	24	15± 6.7	13± 3.8	NA
Garrison:						
Pruess Reservoir	30	9/6	21	21± 8.9	16± 4.1	NA
Rowley Grocery	31	7/13	23	4± 3	7± 3	NA
		8/1	23	<3.4	4± 3	NA
		9/6	23	5± 4	<3.2	NA
Newcastle:						
Municipal Reservoir	70	7/7	21	17± 5.7	11± 3.6	NA
		8/1	21	14± 5.5	13± 4.0	NA
		9/6	21	<3.2	3± 3	NA
Newcastle Diary	71	7/6	24	<3.6	18± 2.8	NA
		8/1	24	5± 4	8± 4	NA
		9/7	24	<6.4	5± 3	NA
St. George:						
R. Cox Diary	82	7/5	24	<3.8	7± 3	NA
		8/1	24	4± 2	<3.3	NA
		9/5	24	<2.4	<3.1	NA

[a] Two-sigma counting error provided when available.
NA, no analysis.
NS, no sample.

[b] 21–Pond, lake, reservoir, stock tank, stock pond.
22–Stream, river, creek.
23–Well
24–Multiple supply mixed (a water sample consisting of mixed or multiple sources of water, such as well and spring).
27–Spring

204

and comparing sample concentrations with both the AEC concentration guides and the PHS drinking water standards, selected samples will be given special analyses at least once a year beginning with samples taken during calendar year 1972. For surface water samples, the special analyses will include strontium-89, strontium-90, plutonium-238, plutonium-239, uranium, and radium-226. For surface water samples, the analyses will include strontium-89, strontium-90, uranium, and radium-226.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

205

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the Mexican National Institute of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January–December 1970	December 1971
Mexican air monitoring program	May–August 1972	January 1973
Plutonium in airborne particulates	April–June 1972	January 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January–December 1969	February 1972

1. Radiation Alert Network, November 1972

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 69 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N. C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1972.

High readings were reported in precipitation samples for the following station: Richmond, Va.—20 nCi/m².[1] All other field estimates reported were within normal limits for the reporting station.

---

[1] This value is suspect due to operational procedures.

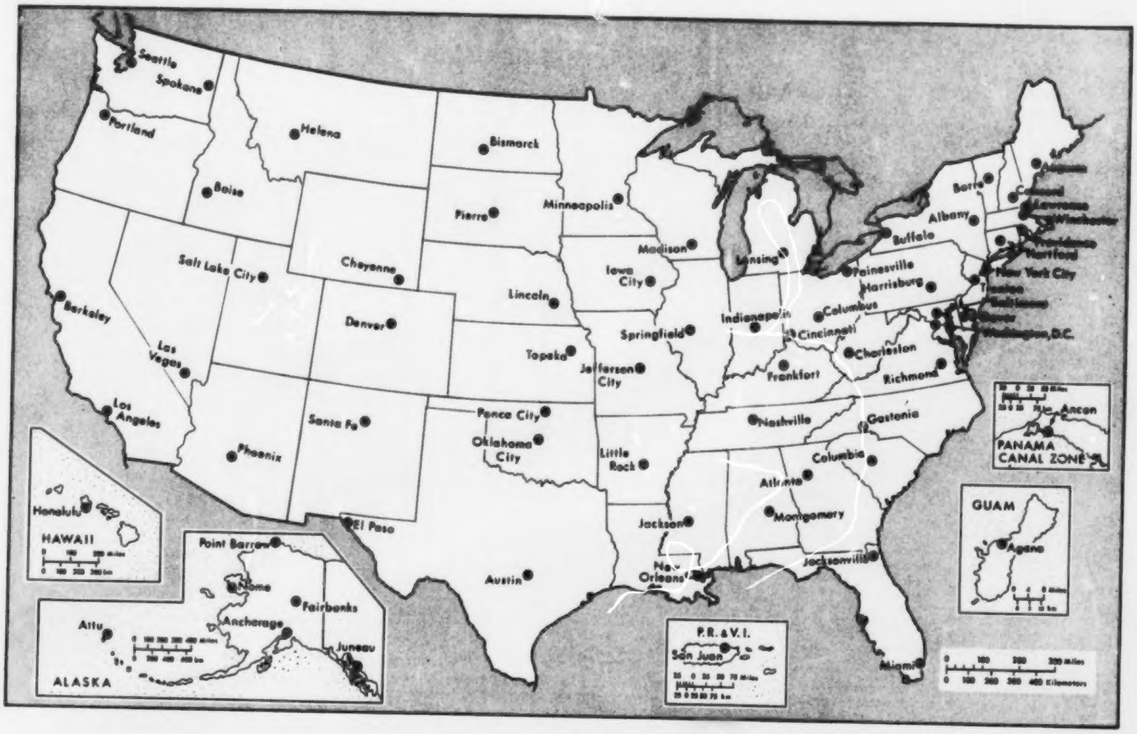
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Buffalo
Albany
Barre
Salt Lake City
Cheyenne
Iowa City
Painesville
Harrisburg
Hartford
New York City
Trenton
Washington, D.C.
Berkeley
Lincoln
Denver
Indianapolis
Columbus
Springfield
Cincinnati
Las Vegas
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
New Orleans
Jacksonville
Austin
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1972

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Precipitation			
			Maximum	Minimum	Average [a]		Total depth (mm)	Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	20	1	0	0	4	85	4	85	9
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	30	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	19	10	1	4	0				
Ark:	Little Rock	13	1	0	0	0				
Calif:	Berkeley	19	1	0	0	7	150	7	150	0
	Los Angeles	20	2	0	1	0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	20	2	0	1	2	7	([b])		
Conn:	Hartford	21	1	0	0	9	140	9	140	0
Del:	Dover	18	0	0	0	0				
D.C:	Washington	24	1	0	0	0				
Fla:	Jacksonville	20	2	0	0	8	110	8	110	0
	Miami	0				0				
Ga:	Atlanta	8	1	0	0	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	3	29	([b])		
Idaho:	Boise	21	4	9	1	3	25	3	25	2
Ill:	Springfield	18	2	0	0	0				
Ind:	Indianapolis	18	0	0	0	0				
Iowa:	Iowa City	[illegible]	1	0	0	4	50	4	50	0
Kans:	Topeka	[illegible]	1	0	1	8	70	8	70	1
Ky:	Frankfort	12	1	9	0	0				
La:	New Orleans	19	1	0	0	8	157	([b])		
Maine:	Augusta	21	1	0	0	7	118	7	118	0
Md:	Baltimore	20	1	0	0	6	53	6	53	0
Mass:	Lawrence	19	1	0	0	6	154	6	154	0
	Winchester	19	1	0	0	7	155	7	155	0
Mich:	Lansing	21	0	0	0	8	52	8	52	5
Minn:	Minneapolis	20	2	0	1	3	40	3	40	2
Miss:	Jackson	10	1	0	0	5	69	5	69	0
Mo:	Jefferson City	18	1	0	0	7	98	7	98	0
Mont:	Helena	18	2	0	1	1	9	1	9	0
Nebr:	Lincoln	21	2	0	1	5	96	5	96	16
Nev:	Las Vegas	19	5	0	2	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	8	195	8	195	3
N. Mex:	Santa Fe	16	1	0	1	0				
N.Y:	Albany	14	1	0	1	0				
	Buffalo	20	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	9	1	3	2	48			
N. Dak:	Bismarck	20	4	1	2	1	3	1	3	0
Ohio:	Cincinnati	0				0				
	Columbus	4	2	0	0	0				
	Painesville	18	0	0	0	9	95	9	95	21
Okla:	Oklahoma City	12	6	0	1	0				
	Ponca City	0				0				
Oreg:	Portland	21	0	9	0	16	115	16	115	3
Pa:	Harrisburg	16	1	0	0	4	101	4	101	16
P.R:	San Juan	0				0				
R.I:	Providence	20	0	0	0	0				
S.C:	Columbia	9	2	0	0	4	131	4	131	1
S. Dak:	Pierre	19	5	1	2	0				
Tenn:	Nashville	18	1	0	0	7	142	7	142	1
Tex:	Austin	21	6	1	2	7	68	([b])		
	El Paso	17	3	0	2	0				
Utah:	Salt Lake City	27	1	0	1	5	27	5	27	15
Vt:	Barre	18	1	0	0	8	127	8	127	5
Va:	Richmond	19	0	0	0	8	433	8	433	[c]75
Wash:	Seattle	8	0	0	0	6	71	([b])		
	Spokane	15	2	0	1	0				
W. Va:	Charleston	19	1	0	0	13	121	13	121	13
Wisc:	Madison	20	1	0	0	4	30	4	30	1
Wyo:	Cheyenne	12	2	0	1	1	4	1	4	0
Network summary		1,008	10	0	1	214	112	6	100	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.
[c] This datum is suspect due to operational procedures.

208

2. Canadian Air and Precipitation Monitoring Program,[1] November 1972

Radiation Protection Division, Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for November 1972 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1972

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	4	0.0	0.0	0.0	59	0.3
Coral Harbour	4	.0	.0	.0	54	.7
Edmonton	4	.0	.0	.0	20	.6
Ft. Churchill	4	.0	.0	.0	28	.3
Fredericton	4	.0	.0	.0	8	1.0
Goose Bay	4	.0	.0	.0	5	.4
Halifax	4	.0	.0	.0	4	.9
Inuvik	4	.0	.0	.0	11	.2
Montreal	4	.0	.0	.0	5	.5
Moosonee	4	.0	.0	.0	14	.4
Ottawa	4	.0	.0	.0	7	.5
Quebec	4	.0	.0	.0	NS	NS
Regina	4	.1	.0	.0	27	.3
Resolute	4	.0	.0	.0	40	.2
St. John's, Nfld	4	.0	.0	.0	3	.7
Saskatoon	4	.0	.0	.0	35	.3
Sault Ste. Marie	4	.0	.0	.0	20	1.3
Thunder Bay	4	.0	.0	.0	21	.7
Toronto	4	.0	.0	.0	5	.4
Vancouver	4	.0	.0	.0	11	1.2
Whitehorse	4	.0	.0	.0	49	.2
Windsor	0	NS	NS	NS	11	.1
Winnipeg	4	.0	.0	.0	35	.4
Yellowknife	4	.1	.0	.0	15	.3
Network summary	92	0.1	0.0	0.0	21	0.5

NS, no sample.

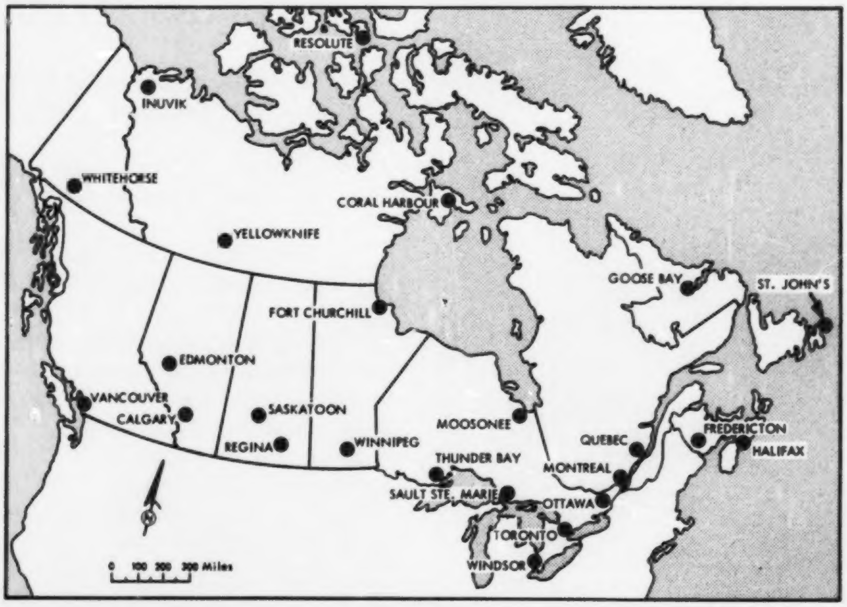
RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
ST. JOHN'S
FORT CHURCHILL
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
THUNDER BAY
MONTREAL
SAULT STE. MARIE
OTTAWA
TORONTO
WINDSOR
0 100 200 300 Miles

Figure 2. Canadian air and precipitation monitoring program

---

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

209

3. Pan American Air Sampling Program
November 1972

Pan American Health Organization and
U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The November 1972 air monitoring results from the participating countries are given in table 3.

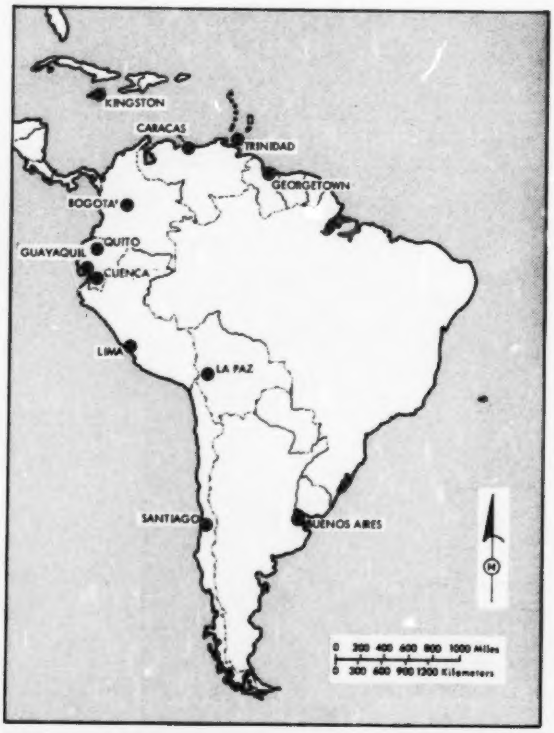

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1972

Station location		Number of samples	Gross beta radioactivity (pCi/m^3)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	13	0.07	0.00	0.02
Chile:	Santiago	23	.05	.00	.03
Colombia:	Bogota	21	.01	.00	.00
Ecuador:	Cuenca	0			
	Guayaquil	18	.04	.00	.02
	Quito	5	.00	.00	.00
Guyana:	Georgetown	4	.00	.00	.00
Jamaica:	Kingston	0			
Peru:	Lima	0			
Venezuela:	Caracas	7	.00	.00	.00
West Indies:	Trinidad	20	.07	.00	.02
Pan American summary		111	0.07	0.00	0.02

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

4. California Air Sampling Program
November 1972

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continuous sampling of air filtered through a 47

210

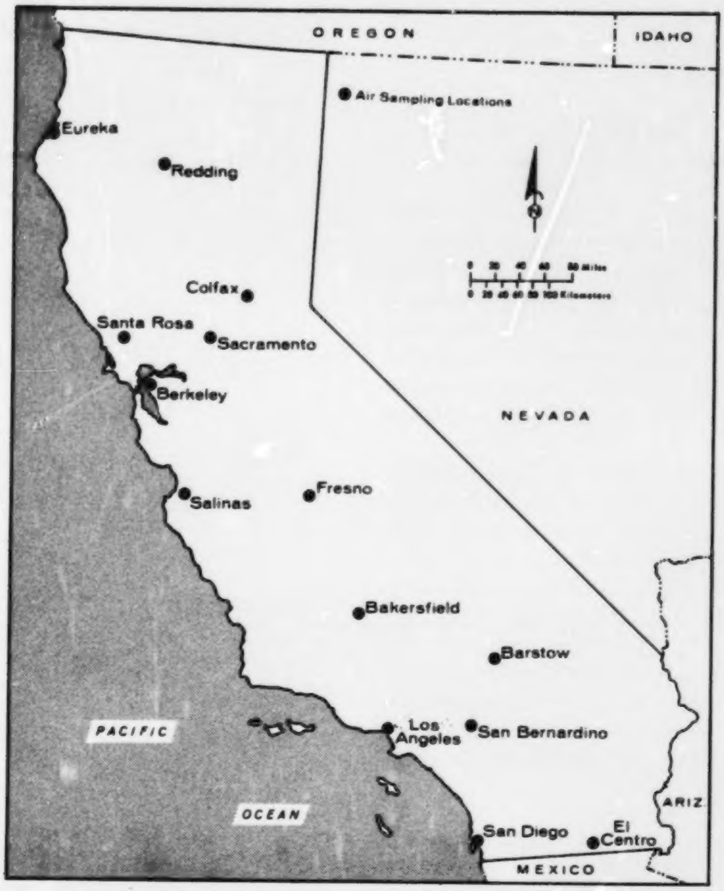
OREGON
IDAHO
Air Sampling Locations
0 20 40 60 80 Miles
0 20 40 60 80 100 Kilometers
Eureka
Redding
Colfax
Santa Rosa
Sacramento
Berkeley
NEVADA
Salinas
Fresno
Bakersfield
Barstow
PACIFIC
Los Angeles
San Bernardino
OCEAN
ARIZ.
San Diego
El Centro
MEXICO

Figure 4. California air sampling program stations

millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium-89 and strontium-90. Table 4 presents the monthly gross beta radioactivity in air for November 1972. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air November 1972

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	24	0.36	0.02	0.11
Barstow	29	1.04	.02	.24
Berkeley	29	.17	.00	.05
Colfax	22	.34	.00	.11
El Centro	30	.87	.01	.23
Eureka	29	.12	.00	.03
Fresno	29	1.15	.00	.14
Los Angeles	29	.15	.00	.07
Redding	30	.28	.00	.05
Sacramento	30	.71	.00	.09
Salinas	30	2.52	.00	.29
San Bernardino	27	.39	.00	.11
San Diego	30	.45	.03	.10
Santa Rosa	30	.12	.00	.05
Summary	398	2.52	0.00	0.12

5. Plutonium in Airborne Particulates July–September 1972

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (*6*).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Facility, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from July–September 1972 are presented in table 5. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

Table 5. Plutonium in airborne particulates July–September 1972

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	Plutonium-239/ plutonium-238
Alaska:	Anchorage	0.4±0.2	13.9±3.5	35±19
Ariz:	Phoenix	2.0± .4	31.2±2.8	16± 3
Colo:	Denver	1.9± .4	16.5±1.5	9± 2
Hawaii:	Honolulu	1.9± .5	19.5±2.0	10± 3
La:	New Orleans	3.0± .5	25.2±2.3	8± 2
Md:	Baltimore	1.8± .4	30.7±2.7	17± 4
N.Y:	Buffalo	1.5± .3	40.7±3.3	27± 6
N.C:	Gastonia	3.7± .8	22.7±2.5	6± 2
S. Dak:	Pierre	3.3± .6	38.1±3.4	12± 2
Tex:	Austin	2.0± .4	42.2±3.4	21± 5
Wash:	Seattle	.5± .2	19.7±2.0	39±16

Other coverage in *Radiation Data and Reports:*

Period	Issue
July–September 1971	April 1972
Octboer–December 1971	July 1972
January–March 1972	December 1972
April–June 1972	January 1973

REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Air Surveillance Network, November 1972

National Environmental Research Center—Las Vegas,[1] Environmental Protection Agency

The Air Surveillance Network (ASN), operated by the National Environmental Research Center—Las Vegas (NERC-LV), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

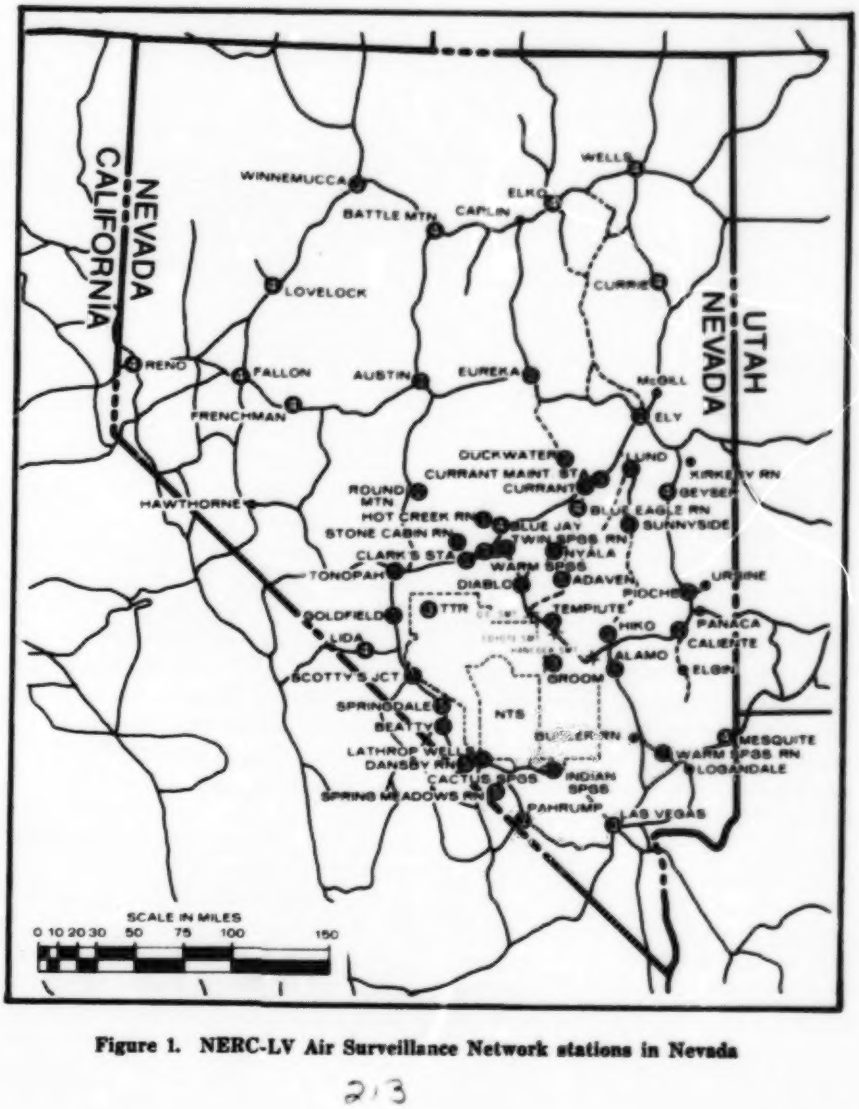
NEVADA
CALIFORNIA
UTAH
NEVADA
WINNEMUCCA
BATTLE MTN
CARLIN
ELKO
WELLS
LOVELOCK
CURRIE
RENO
FALLON
AUSTIN
EUREKA
McGILL
FRENCHMAN
ELY
DUCKWATER
CURRANT MAINT ST
CURRANT
LUND
KIRKEBY RN
GEYSER
ROUND MTN
HAWTHORNE
HOT CREEK RN
BLUE JAY
BLUE EAGLE RN
SUNNYSIDE
STONE CABIN RN
TWIN SPGS RN
CLARK'S STA
NYALA
WARM SPGS
TONOPAH
DIABLO
ADAVEN
URSINE
PIOCHE
GOLDFIELD
TTR
TEMPIUTE
HIKO
PANACA
CALIENTE
LIDA
ALAMO
ELGIN
SCOTTY'S JCT
GROOM
SPRINGDALE
NTS
BEATTY
BUSTER RN
MESQUITE
WARM SPGS RN
LOGANDALE
LATHROP WELLS
DANSBY RN
CACTUS SPGS
INDIAN SPGS
SPRING MEADOWS RN
PAHRUMP
LAS VEGAS
SCALE IN MILES
0 10 20 30 50 75 100 150

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

---

[1] Formerly the Western Environmenal Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26-1)-539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

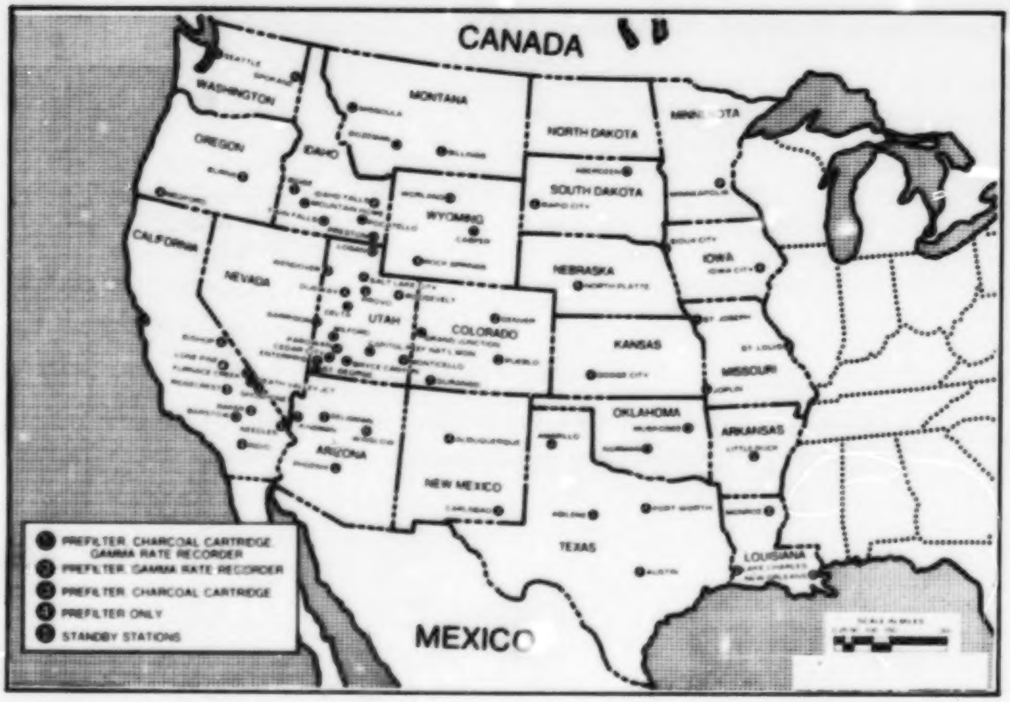
CANADA
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
COLORADO
ARIZONA
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
MEXICO
PREFILTER, CHARCOAL CARTRIDGE, GAMMA RATE RECORDER
PREFILTER, GAMMA RATE RECORDER
PREFILTER, CHARCOAL CARTRIDGE
PREFILTER ONLY
STANDBY STATIONS

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC-LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports*.

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was less than 0.4 pCi/m^3 at Denver, Colo., based on a small volume of 81 m^3. The highest concentration based on normal sample volume was 0.2 pCi/m^3 at Worland, and Rock Springs, Wyo., and Duckwater, Nev. The minimum reported concentration for gross beta is 0.1 pCi/m^3. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m^3) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level are reported as less than 0.1 pCi/m^3. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during November.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC-LV upon written request.

Table 1. Summary of gross beta radioactivity concentrations in air, November 1972

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	30	0.1	<0.1	0.1
	Phoenix	28	.1	<.1	.1
	Seligman	29	<.1	<.1	.1
	Winslow	30	<.1	<.1	.1
Ark:	Little Rock	16	<.1	<.1	.1
Calif:	Baker	29	.1	<.1	.1
	Barstow	29	<.1	<.1	.1
	Bishop	30	<.2	<.1	.1
	Death Valley Junction	30	<.2	<.1	.1
	Furnace Creek	30	.1	<.1	.1
	Indio	30	<.1	<.1	.1
	Lone Pine	29	<.1	<.1	.1
	Needles	28	<.1	<.1	.1
	Ridgecrest	30	.1	<.1	.1
	Shoshone	30	<.1	<.1	.1
Colo:	Denver	21	<.4	<.1	.1
	Durango	20	<.1	<.1	.1
Idaho:	Boise	29	<.1	<.1	.1
	Idaho Falls	20	.1	<.1	.1
	Preston	31	<.3	<.1	.1
	Twin Falls	29	<.1	<.1	.1
Iowa:	Iowa City	17	<.1	<.1	.1
	Sioux City	24	.1	<.1	.1
Kans:	Dodge City	30	<.1	<.1	.1
La:	Lake Charles	20	.1	<.1	.1
	Monroe	19	<.1	<.1	.1
	New Orleans	17	.1	<.1	.1
Minn:	Minneapolis	21	.1	<.1	.1
Mo:	Joplin	30	<.1	<.1	.1
	St. Joseph	30	<.1	<.1	.1
	St. Louis	30	<.1	<.1	.1
Nebr:	North Platte	27	<.3	<.1	.1
Nev:	Alamo	30	.1	<.1	.1
	Austin	23	<.1	<.1	.1
	Battle Mountain	29	<.1	<.1	.1
	Beatty	30	<.1	<.1	.1
	Blue Eagle Ranch (Currant)	28	<.2	<.1	.1
	Blue Jay	30	.1	<.1	.1
	Caliente	30	.1	<.1	.1
	Currant Ranch	29	<.1	<.1	.1
	Currie	30	<.1	<.1	.1
	Diablo	30	<.1	<.1	.1
	Duckwater	24	.2	<.1	.1
	Elko	30	<.1	<.1	.1
	Ely	29	<.1	<.1	.1
	Eureka	30	<.1	<.1	.1
	Fallini's Twin Springs Ranch	30	<.1	<.1	.1
	Fallon	30	<.1	<.1	.1
	Frenchman Station	30	.1	<.1	.1
	Geyser Maintenance Station	29	<.1	<.1	.1
	Goldfield	23	<.1	<.1	.1
	Groom Lake	23	<.1	<.1	.1
	Hiko	30	.1	<.1	.1
	Indian Springs	30	<.1	<.1	.1
	Las Vegas	21	.1	<.1	.1
	Lathrop Wells	30	.1	<.1	.1
	Lida	30	<.1	<.1	.1
	Lovelock	30	.1	<.1	.1
	Lund	28	<.1	<.1	.1
	Mesquite	30	.1	<.1	.1
	Nyala	27	<.1	<.1	.1
	Pahrump	22	<.1	<.1	.1
	Pioche	30	<.1	<.1	.1
	Reno	30	<.1	<.1	.1
	Round Mountain	29	<.1	<.1	.1
	Scotty's Junction	29	<.1	<.1	.1
	Stone Cabin Ranch	30	<.1	<.1	.1
	Sunnyside	27	<.1	<.1	.1
	Tonopah	30	<.1	<.1	.1
	Tonopah Test Range	27	<.1	<.1	.1
	Warm Springs	30	<.1	<.1	.1
	Warm Springs Ranch	30	.1	<.1	.1
	Wells	30	.1	<.1	.1
	Winnemucca	31	<.3	<.1	.1
N. Mex:	Albuquerque	22	<.3	<.1	.1
	Carlsbad	24	.1	<.1	.1
Okla:	Muskogee	29	<.1	<.1	.1
Oreg:	Burns	26	<.1	<.1	.1
	Medford	28	<.1	<.1	.1
S. Dak:	Aberdeen	30	<.1	<.1	.1
	Rapid City	28	<.1	<.1	.1
Tex:	Abilene	14	.1	<.1	.1
	Amarillo	30	.1	<.1	.1
	Austin	18	.1	<.1	.1
	Fort Worth	28	<.1	<.1	.1
Utah:	Bryce Canyon	19	<.1	<.1	.1
	Cedar City	28	<.1	<.1	.1
	Delta	30	<.1	<.1	.1

See footnote at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, November 1972—continued

Location		Number of samples	Concentration (pCi/m^3)		
			Maximum	Minimum	Average [a]
Utah:	Dugway	30	<.1	<.1	.1
	Enterprise	30	<.1	<.1	.1
	Garrison	30	<.1	<.1	.1
	Logan	30	.1	<.1	.1
	Milford	30	<.1	<.1	.1
	Monticello	30	<.1	<.1	.1
	Parowan	28	<.1	<.1	.1
	Provo	29	<.1	<.1	.1
	Roosevelt	30	.1	<.1	.1
	Salt Lake City	30	<.1	<.1	.1
	St. George	30	.1	<.1	.1
	Wendover	30	<.1	<.1	.1
Wash:	Seattle	21	<.1	<.1	.1
	Spokane	14	.1	<.1	.1
Wyo:	Rock Springs	30	.2	<.1	.1
	Worland	30	.2	<.1	.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m^3 is reported as <0.1.

216

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

A summary of the environmental radioactivity data follow for Bettis Atomic Power Laboratory and the Mound Laboratory.

Bettis Atomic Power Laboratory [2]
January–December 1971

Westinghouse Electric Corporation
Pittsburgh, Pa.

The Bettis Atomic Power Laboratory is operated by the Westinghouse Electric Corporation for the U.S. Atomic Energy Commission and is situated on a 200-acre tract of land in the Borough of West Mifflin, Pa., approximately 7 miles southeast of the city of Pittsburgh. The Facility consists of a main laboratory area and a critical facility area and is engaged in the design and development of nuclear power reactors in support of the naval reactors program of the Atomic Energy Commission. A map of the Bettis Laboratory and surrounding area is provided in figure 1.

This document summarizes the disposal of radioactive liquid, airborne, and solid waste products which originate from the design and development activities conducted at the laboratory for January–December 1971. Solid radioactive waste materials are shipped offsite in approved sealed containers for land burial and have no effect on the environs surrounding the laboratory. Radioactive liquid and airborne effluents are treated prior to being released and all such discharges to the environment are limited to the lowest amount practical. Upper limits on discharges are based on the values recommended in 10CFR20, AEC Manual, Chapter 0524, and Pennsylvania Rules and Regulations Article 433.

An environmental monitoring program has been maintained at the laboratory since 1959 and provides a means of monitoring the stringent control of radioactive discharges from the facility. The program also ensures compliance with the applicable State and federal radioactivity standards and ascertains that the health and safety of the general public is protected.

---

[1] Title 10, Code to Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

[2] Summarized from "Bettis Atomic Power Laboratory, Effluent and Environmental Monitoring Report, Calendar Year 1971" (WAPD-RS(EA)-31).

217

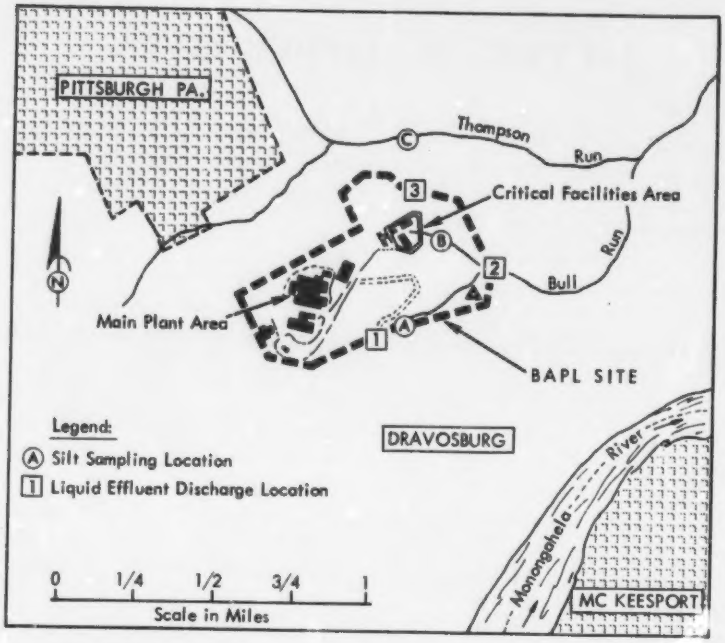
PITTSBURGH PA.
Thompson
Run
C
3
Critical Facilities Area
B
2
Bull
Run
N
Main Plant Area
1
A
BAPL SITE
Legend:
A Silt Sampling Location
1 Liquid Effluent Discharge Location
DRAVOSBURG
River
Monongahela
0
1/4
1/2
3/4
1
Scale in Miles
MC KEESPORT

Figure 1. Bettis Atomic Power Laboratory sampling stations

Liquid radioactive waste

Laboratory radioactive liquids are collected in retention tanks and are treated by either filtration, ion exchange, or evaporation until the activity levels obtained are as low as practical. All liquid effluents released to the environment are sampled and stringently controlled to ensure that the quantity of activity is small and that the activity concentrations are well below the laboratory discharge limit. Laboratory liquid effluents are released at the locations shown in figure 1. All three of the liquid effluent discharge sources are small brooks which neither support aquatic life nor are utilized for irrigation or drinking purposes. The radioactive constituents contained in the liquid effluent which are attributable to laboratory operations are strontium-90 and cesium-137 but these are present in very low concentrations. The net quantity of radioactivity released to the environment attributable to laboratory operations during 1971 was only 0.011 curie or 5.1 percent of the applicable laboratory discharge limit which is based on the maximum permissible concentration of strontium-90 in water as specified in 10CFR 20.

Airborne radioactivity monitoring

All radioactive laboratory exhaust air is filtered prior to being released to the environment through continuously monitored stacks. For 1971, less than 0.11 curie of particulate radioactivity was released from the laboratory exhaust stacks. This is equivalent to less than 10 percent of the concentration guide for an unknown mixture of radionuclides in air at the site boundary. Monitoring confirmed that at no time during 1971 did the exhaust air discharges from any of the stacks exceed one tenth of the AEC concentration guides for air and in fact the activity in many stacks was less than the minimum detectable level. No observable effect in excess of background radiation was detected on the perimeter film badges and the general public was not exposed to radiation exposure above background as a result of laboratory operations.

Stream silt

Stream silt samples are periodically collected downstream from the three laboratory discharge locations and also from a control stream in which laboratory liquid effluents are not discharged. A 2-year comparison of the laboratory average net silt radioactivity with the natural radioactivity detected in the Streets Run control stream silt samples is shown in table 1. The table shows that there is a wide fluctuation in the natural radioactivity levels in the Streets Run control stream and that the radioactivity levels detected in the 3 laboratory brooks are low and decreasing.

Table 1. Radioactivity in stream silt Bettis Laboratory, 1970–1971

Year	Detected silt radioactivity attributable to laboratory operations (pCi/g)		Detected silt radioactivity in the Streets Run control stream (pCi/g)	
	Alpha	Beta-gamma	Alpha	Beta-gamma
1970	4.0	29.0	3.5	23.0
1971	3.8	19.9	.9	5.4

Monongahela River water

The brooks into which laboratory effluent is discharged eventually empty into the Monongahela River. Downstream measurements of radioactivity in Monongahela River water for June 1971 are reported in reference (*1*) for 2 locations. Similar measurements (*1*) were also obtained from the Beaver River, which is also a tributary of the Ohio River. There are no nuclear facilities located along the Beaver River watershed. A comparison of these data show that the measured radioactivity in the Monongahela River water is equal to or less than the levels measured in the Beaver River. Similar conclusions for March 1971 are drawn from data in reference (*2*). It is concluded from these data that Bettis operations had no effect on the radioactivity levels in the Monongahela River water.

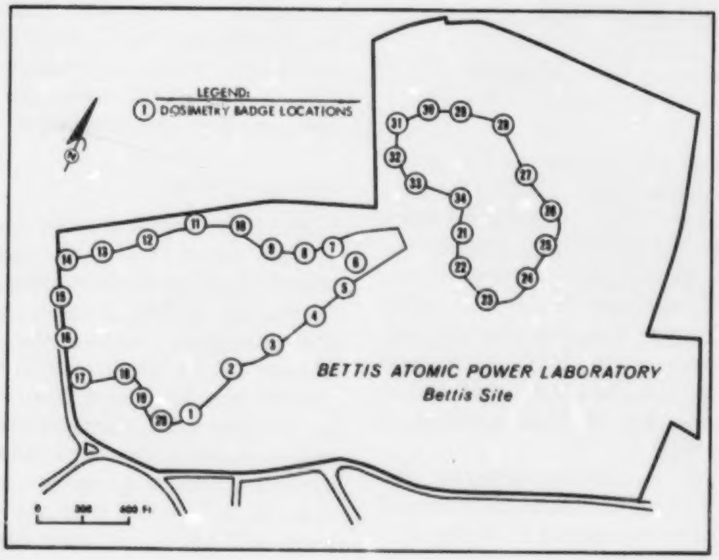

Figure 2. Dosimetry badge locations, BAPL

Stream vegetation

Vegetation samples were collected from the 3 laboratory brooks and also from the Streets Run control stream. The radioactivity measurements obtained from the vegetation samples showed no significant difference from the level obtained from the control stream vegetation samples. It is concluded therefore that the operation of the laboratory has had no significant environmental effect on the plant and wildlife in the vicinity of the laboratory.

Perimeter monitoring

Environmental monitoring film badges were placed at 34 locations on the perimeter fence of the laboratory as shown in figure 2 and compared with the radiation levels measured on 9 nearby control badges. No difference in radiation levels was observed between that at the Bettis perimeter and natural background. From this comparison, it is concluded that the general public did not receive radiation exposure greater than natural background as a result of Bettis operations. Stringent control of Bettis operations has resulted in low levels of radioactivity in the laboratory liquid and airborne effluents; measurements of Monongahela River water show no detectable radioactivity caused by Bettis operations and the Bettis operations have caused no exposure to members of the general public above natural background levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1971	November 1971

REFERENCES

(*1*) ENVIRONMENTAL PROTECTION AGENCY. Gross radioactivity in surface waters of the United States June 1971. Rad Health Data Rep 13:81 (February 1972).

(*2*) ENVIRONMENTAL PROTECTION AGENCY. Gross radioactivity in surface waters of the United States, March 1971. Rad Health Data Rep 12:572–573 (November 1971).

---

2. Mound Laboratory[3]
July–December 1970

Monsanto Research Corporation
Miamisburg, Ohio

Mound Laboratory is situated on 180 acres of land in Miamisburg, Ohio, about 12 miles southwest of Dayton. The laboratory began operation in 1949. Its mission currently includes research, development, engineering, and production of components for the AEC weapons program; separation, purification, and sale of stable isotopes of the noble gases; and development, design, and fabrication of radioisotopic heat sources for medical application and space exploration.

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specified for the radionuclides which could be released to the environment. Only polonium-210, plutonium-238, and hydrogen-3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, was used for measuring tritium and particulate alpha-particle emitters in the air within a radius of 20 miles from the laboratory during the collection period (figure 3). In August 1970, the sampling frequency was increased from once per week to 3 times per week. Samples are collected upwind and downwind from the laboratory. Since the sampling zone is dependent on the wind direction, it is possible that air samples from all zones will not be collected during the reporting period.

Airborne polonium and plutonium particulates are collected on Whatman No. 41 filter

---

[3] Summarized from "Environmental Monitoring Report," July-December 1970 and 1970 Summary (MLM 1795).

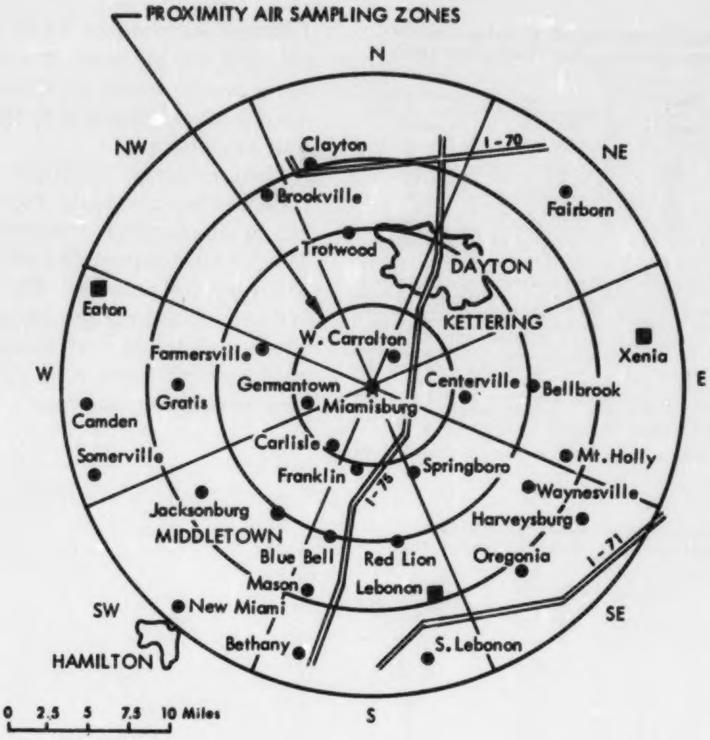
PROXIMITY AIR SAMPLING ZONES
N
NW
NE
W
E
SW
SE
S
I-70
I-75
I-71
Clayton
Brookville
Fairborn
Trotwood
DAYTON
KETTERING
Eaton
Xenia
W. Carrolton
Farmersville
Germantown
Centerville
Bellbrook
Gratis
Miamisburg
Camden
Carlisle
Somerville
Mt. Holly
Franklin
Springboro
Waynesville
Jacksonburg
Harveysburg
MIDDLETOWN
Blue Bell
Red Lion
Oregonia
Mason
Lebanon
New Miami
Bethany
S. Lebanon
HAMILTON
0
2.5
5
7.5
10 Miles

Figure 3. Offsite air sampling zones, Mound Laboratory

paper with a high-volume air sampler. A 5-cm diameter circle, cut from the center of each filter paper, is processed and analyzed for plutonium-238.

Airborne tritium oxide is monitored by bubbling air through 100-ml of a liquid scintillation counting solution with p-dioxane as the organic solvent. A 20-ml aliquot of the resulting solution is counted directly in a liquid scintillation spectrometer for 10 minutes. The analysis is directed to tritium oxide rather than the gas because the AEC standard for the oxide is 200 times more restrictive than for the gas.

The results of the airborne monitoring program are presented in tables 2, 3, and 4. The average concentrations of polonium-210, plu-

Table 2. Atmospheric monitoring of polonium-210 Mound Laboratory environs, July–December 1970

Range (miles)	Number of samples	Average concentration [a] (fCi/m³)	Average as percent of AEC standards [b]
0– 3 (upwind)	59	15	0.08
0– 3 (downwind)	59	8	.04
3– 5 (downwind)	58	10	.05
5–10 (downwind)	59	9	.05
10–15 (downwind)	59	11	.06
15–20 (downwind)	59	6	.03

[a] Lowest detectable level (LDL) for polonium-210 in air is 8 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 5 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which polonium-210 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at two locations within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 33 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.

[b] The applicable AEC radiation protection standard for polonium-210 in air is 20 pCi/m³.

Table 3. Atmospheric monitoring of plutonium-238 Mound Laboratory environs, July–December 1970

Range (miles)	Number of samples	Average concentration [a] (fCi/m³)	Average as percent of AEC standards [b]
0– 3 (upwind)	57	2.8	0.28
0– 3 (downwind)	57	1.5	.15
3– 5 (downwind)	57	1.9	.19
5–10 (downwind)	57	2.1	.21
10–15 (downwind)	57	2.2	.22
15–20 (downwind)	57	1.9	.19

[a] Lowest detectable level (LDL) for plutonium-238 in air is 1.3 fCi/m³ for samples collected 0–3 miles upwind, 3–5 miles downwind, 5–10 miles downwind, and 10–15 miles downwind. The LDL is 0.9 fCi/m³ for samples collected 0–3 miles downwind and 15–20 miles downwind. Two LDL's are expressed above for the ranges in which plutonium-238 samples are collected. Air is sampled at three locations within the 0–3 and 15–20 mile downwind ranges, and the filter papers are combined to form one composite sample for each range. Air samples in other ranges are comprised of samples collected at two locations within each range. Since the volume of air analyzed in the 0–3 and 15–20 mile downwind ranges is 38 percent greater than in the other ranges, the sensitivity expressed as LDL is proportionately lower.

[b] The applicable AEC radiation protection standard for plutonium-238 in air is 1 pCi/m³.

Table 4. Atmospheric monitoring of tritium Mound Laboratory environs, July–December 1970

Range (miles)	Number of samples	Average concentration [a] (pCi/m³)	Average as percent of AEC standards [b]
0– 3 (upwind)	57	530	0.26
0– 3 (downwind)	58	3,400	1.70
3– 5 (downwind)	58	730	.36
5–10 (downwind)	59	500	.25
10–15 (downwind)	59	640	.32
15–20 (downwind)	59	540	.27

[a] Lowest detectable limit for tritium in air is 200 pCi/m³.

[b] The applicable AEC radiation protection standard for tritium in air is 200 nCi/m³.

tonium-238, and tritium in the environment are below the AEC radiation protection standards.

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed separately to reduce the concentrations of these radionuclides to a level at which they may be discharged to the environment. Treated polonium liquid waste is discharged to the Great Miami River via a closed sewer line which also carries the treated plant sewage. The treated plutonium waste is discharged to a drainage ditch which runs through the plant site and eventually reaches the river.

Helium-3 being purified at the Mound Laboratory contains small quantities of tritium. In addition, tritium is recovered from various AEC tritium-contaminated wastes. Liquid waste generated by these operations is treated (diluted with water when necessary) and discharged to the same drainage ditch as plutonium waste. Some tritium-contaminated liquid wastes are discharged to the same closed sewer line as polonium.

Two hundred milliliter water samples are collected weekly from the Great Miami River, the drainage ditch and two ponds northeast of Mound Laboratory (figure 4). All samples are analyzed for polonium-210, plutonium-238, and tritium. The average concentrations of plutonium and tritium in water discharged to the environment were well below the AEC radiation protection standards. Average concentra-

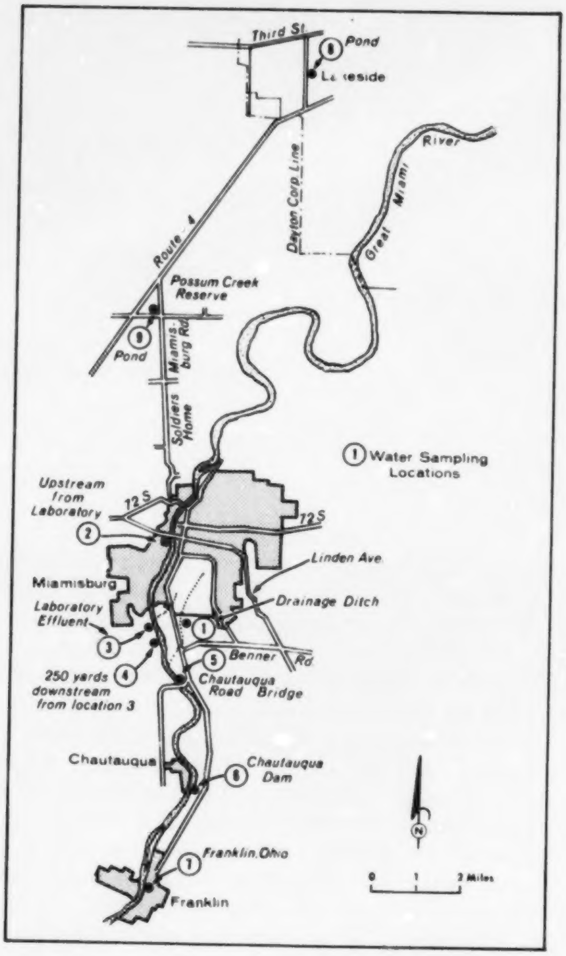
Third St.
⑧ Pond
Lakeside
Dayton Corp. Line
River
Great Miami
Route 4
Possum Creek Reserve
⑨ Pond
Miamisburg Rd.
Soldiers Home
① Water Sampling Locations
Upstream from Laboratory
72 S
72 S
②
Linden Ave.
Miamisburg
Drainage Ditch
Laboratory Effluent
③
①
⑤ Benner Rd.
250 yards downstream from location 3
④
Chautauqua Road Bridge
Chautauqua
⑥ Chautauqua Dam
N
Franklin, Ohio
⑦
0 1 2 Miles
Franklin

Figure 4. Offsite water sampling locations Mound Laboratory

Table 5. Offsite water monitoring for radioactivity, Mound Laboratory environs, July–December 1970

Sampling location [a]	Number of samples [b]	Polonium-210 [c] (pCi/liter)		Plutonium-238 [c] (pCi/liter)		Tritium [c] (hydrogen-3) (nCi/liter)	
		Average [d]	Percent of concentration limit	Average [d]	Percent of concentration limit	Average [d]	Percent of concentration limit
1	38	2.01	0.29	34.4	0.69	352	11.73
2	36	2.51	.36	5.2	.10	11.0	.37
3	38	51.9	7.41	9.2	.18	177	5.90
4	38	2.25	.32	5.4	.11	10.0	.33
5	36	1.85	.26	5.3	.11	9.0	.30
6	38	2.18	.31	6.4	.13	9.0	.30
7	38	1.94	.28	4.6	.09	15.0	.50
8	38	2.54	.36	5.1	.10	11.0	.37
9	36	1.92	.27	5.7	.11	11.0	.37

[a] See figure 4 for number of sampling locations.
Sampling location and description: 1 ,Mound Laboratory drainage ditch; 2, Linden Avenue bridge, upstream from laboratory; 3, Mound Laboratory effluent; 4, 250 yards downstream from location 3; 5, Chautauqua Road Bridge; 6, Chautauqua Dam; 7, Franklin, Ohio; 8, Pond, opposite V.A. hospital, Dayton, Ohio, 8 miles NE of Mound Laboratory; 9, Pond, Possum Creek Reserve, Dayton, Ohio, 6 miles NE of Mound Laboratory.

[b] In August 1970 the sampling frequency was increased from once per week to twice per week. The number of samples for plutonium-238 ranged from 36 to 38.

[c] Lowest detectable level for polonium-210 in water is 1.80 pCi/liter. Lowest detectable level for plutonium-238 in water is 4.5 pCi/liter. Lowest detectable level for tritium in water is 6 nCi/liter.

[d] The applicable AEC radiation protection standard for uncontrolled areas are as follows: polonium-210 in water, 700 pCi/liter; plutonium-238 in water, 5 nCi/liter; tritium in water, 3 µCi/liter.

tions of tritium, polonium-210, and plutonium-238 are given in table 5 for July–December 1970.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January–June 1970	January 1973

223

Nuclear Power Reactors in the United States
December 31, 1972

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

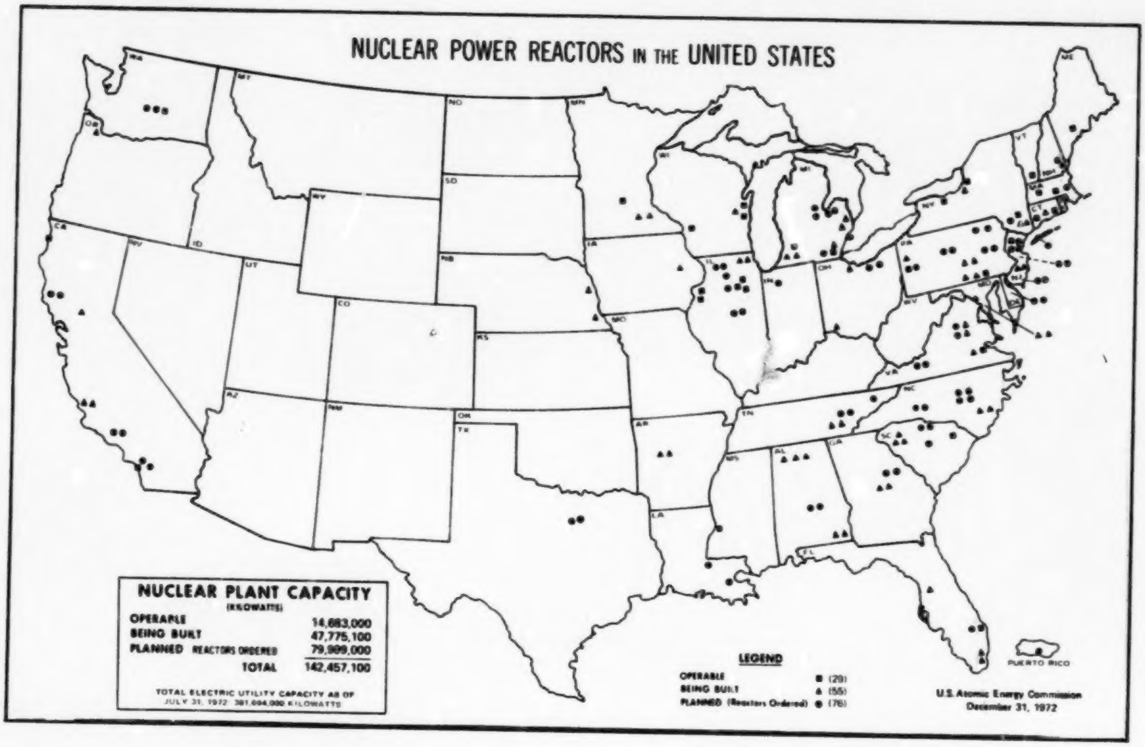
NUCLEAR POWER REACTORS IN THE UNITED STATES
WA
OR
CA
NV
ID
MT
WY
UT
AZ
CO
NM
ND
SD
NB
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
TN
MS
AL
GA
FL
SC
NC
VA
WV
PA
NY
VT
NH
ME
MA
CT
NJ
MD
DE
PUERTO RICO
NUCLEAR PLANT CAPACITY
(KILOWATTS)
OPERABLE 14,683,000
BEING BUILT 47,775,100
PLANNED REACTORS ORDERED 79,999,000
TOTAL 142,457,100
TOTAL ELECTRIC UTILITY CAPACITY AS OF JULY 31, 1972 381,664,000 KILOWATTS
LEGEND
OPERABLE ■ (29)
BEING BUILT ▲ (55)
PLANNED (Reactors Ordered) ● (76)
U.S. Atomic Energy Commission
December 31, 1972

Figure 1. Nuclear power reactors in the United States, December 31, 1972

225

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Selma	Orville: Unit 1	1,100,000	Alabama Power Co.	1981
Selma	Orville: Unit 2	1,100,000	Alabama Power Co.	1982
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1974
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
•	–	770,000	Southern California Edison Co.	1981
•	–	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
DELAWARE				
Middletown	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1978
Middletown	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1981
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	800,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	890,000	Florida Power & Light Co.	1979
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,105,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,105,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	800,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	800,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co. Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co. Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co. Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
Byron	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1979
Byron	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 1	1,100,000		1980
Braidwood	Braidwood: Unit 2	1,100,000		1981
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station	1,165,000	Louisiana Power & Light Co.	1976
St. Francisville	River Bend Station	940,000	Gulf States Utilities Co.	1979

Figure 1. Nuclear power reactors in the United States December 31, 1972—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
Douglas Point	Douglas Point Project: Unit 1	1,100,000	Potomac Electric Power Co.	1980
Douglas Point	Douglas Point Project: Unit 2	1,100,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	655,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,124,000	Detroit Edison Co.	1980
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1977
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1978
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1979
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1981
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,275,000	Mississippi Power & Light Co.	1978
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW HAMPSHIRE				
Seabrook	–	1,100,000	Public Service of N.H.	1979
Seabrook	–	1,100,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1974
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1978
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1979
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980

Figure 1. Nuclear power reactors in the United States December 31, 1972—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Painesville	Perry Nuclear Power Plant: Unit 1	1,100,000	Cleveland Electric Illuminating Co.	1979
Painesville	Perry Nuclear Power Plant: Unit 2	1,100,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1976
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1978
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1979
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co. Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1973
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
*	Philadelphia Electric Co.: HTGR No. 1	1,140,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co.: HTGR No. 2	1,140,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Fast Breeder Demonstration Plant	400,000	Tennessee Valley Authority	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Power & Light	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Power & Light	1982
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	Hanford No. 1	1,120,000	Washington Public Power Supply System	1980
Richland	Hanford No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1972
PUERTO RICO				
Puerto De Jobos	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975
* Site not selected.				
*	–	1,175,000	Tennessee Valley Authority	1977
*	–	1,175,000	Tennessee Valley Authority	1978
*	–	1,120,000	Tennessee Valley Authority	1980
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1982
*	–	900,000	Virginia Electric & Power Company	1980
*	–	900,000	Virginia Electric & Power Company	1981

Figure 1. Nuclear power reactors in the United States December 31, 1972—continued

Reported Nuclear Detonations, February 1973

(Includes seismic signals presumably from foreign nuclear detonations)

Seismic signals, presumably from a Soviet underground nuclear explosion, were recorded by the United States on February 16, 1973. The signals originated shortly after midnight, EST, at the Semipalatinsk nuclear test area and were equivalent to those of an underground nuclear explosion in the yield range of 20-200 kilotons.

There were no reported nuclear detonations for the United States for February 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

☆U.S. Government Printing Office: 1973-514-846/8

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIOBIOASSAY PROGRAM OF THE INSTITUTIONAL TOTAL DIET SAMPLING NETWORK: I. ANALYTICAL DATA RELATED TO SAMPLES COLLECTED DURING 1966–1968. *A. A. Moghissi, M. W. Carter, and R. Lieberman. Radiation Data and Reports*, Vol. *14*, March 1973, pp. 129–144.

In January 1966, a radiobioassay program was added to the Institutional Total Diet Sampling Network program. The sampling and analysis procedures are described and the data for 1966 through 1968 are presented.

KEYWORDS: body burdens, cesium-137, diet, radiobioassay, strontium-90, urine.

STATE ENVIRONMENTAL RADIOACTIVITY SURVEILLANCE PROGRAMS, 1972. *Mary Ann Culliton, Radiation Data and Reports*, Vol. *14*, March 1973, pp. 145–173.

This report presents a summary of State environmental radioactivity surveillance programs for 1972. Information is given in table form on sample media, sites, collection and analysis frequency, and types of analysis performed.

KEYWORDS: air, environment, milk, nuclear facilities, radionuclides, surveillance programs, United States.

230